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OCCASIONAL PAPER No. 50 September 18, 1935.

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SOUTHERN FOREST EXPERIMENT STATION

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KILLING UNDESIRABLE HARDWOODS IN SOUTHERN FORESTS

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This paper releases data gathered in recent and current investigations of the Southern Forest Experiment Station. The information contained herein is subject to correction or modification following further investigation.

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STAND IMPROVEMENT: THE ELIMINATION OF UNDESIRABLE TREES

The improvement of forest stands in the South, as in other forest regions of the United States, is effected largely and often entirely by the felling or killing of undesirable trees. Trees may be considered undesirable because they are variously:

1. - Unmerchantable, even though of merchantable size.

2. - Potentially unmerchantable even when larger, because of species, form, or quality.

3. - Doubtfully merchantable, or of very low value, either now or in the future, and crowding or overtopping desirable crop trees or potential crop trees.

4. - Defective and providing an abundant source of infection to desirable trees.

5. - Crowding more valuable trees to such an extent that the growth of the more valuable trees is seriously retarded.

Stand improvement is applicable throughout the southern forest region, especially in restocking cut-over areas where the growth of valuable young pines is being suppressed or retarded by unmerchantable or less valuable hardwoods. Thousands of acres in this condition in the National Forests of the South have already been covered systematically by stand-improvement or so-called cultural operations, and other millions of acres are in need of such treatment.

There are three basic methods of eliminating undesirable trees from forest stands: (1) by felling or cutting, (2) by girdling, and (3) by poisoning. These methods will be considered in turn, discussed in some detail, compared and evaluated, and a brief summary will be presented in the form of conclusions. This paper deals only with the killing of undesirable hardwoods. It does not consider *which* or *how many* hardwoods should be eliminated as undesirable, but only the different methods of eliminating undesirable hardwoods, once chosen. Stand improvement--like most other beneficial treatments--can be overdone, and every tree that falls into one of the five categories of the first paragraph should not necessarily be eliminated from a given stand. The list is given only to describe specifically the kind of trees that under various circumstances often need to be removed from further competition in a stand by one of the methods discussed below. Another point to be borne in mind is that the criterion of success in killing undesirable hardwoods in stand-improvement work is largely the death of the crown, or at least the removal of the crown competition, and secondarily the prevention or reduction of undesirable sprouting, of single trees or groups of trees. This paper does not consider the complete elimination of entire stands for the purpose of planting with desirable species, or for agricultural or other nonforest use.

SOURCES OF INFORMATION

In preparing this paper, experimental data collected by the Southern Forest Experiment Station have comprised the principal source of information. The forest types and localities from which these data were collected are as follows: Shortleaf pine-mixed hardwood type on the Ouachita National Forest, near Mount Ida, Ark.; loblolly-shortleaf-mixed hardwood type near Urania, La.; and longleaf pine-scrub oak types on the Choctawhatchee National Forest, near Valparaiso, Fla., and on the Kisatchie National Forest, near Pollock, La.

Two other important sources of information have been: (1) Observations made by the writers in various parts of the deep South, and (2) publications, mimeographed material, and typewritten reports, not necessarily applying directly to the South. Observations of the results of cutting, girdling, or poisoning have been made in the loblolly-shortleaf-hardwoods type on the Homochitto Division of the DeSoto National Forest in southern Mississippi, and on Texas State Forest No. 1, near Kirbyville, Tex.; and in the longleaf-scrub oak type on Texas State Forest No. 1, and on the University Forest, near Vancleave, Miss. A bibliography of the books, articles, bulletins, and reports that have been consulted will be found at the end of this paper.

Since many of the publications present data that conflict more or less with other publications or with our own observations and experiments, it has been necessary to sift and weigh all available information very carefully before drawing conclusions. In arriving at conclusions, our own data and experiences have naturally been relied on most heavily, but not exclusively. The conclusions concerning the poisoning of undesirable trees, as derived from our own observations and experiments, are substantiated in general by unpublished, comprehensive experimental data secured and analyzed by Mr. G. R. Boyd of the Bureau of Agricultural Engineering, U. S. Department of Agriculture.

METHODS OF ELIMINATING UNDESIRABLE TREES

FELLING

Felling is, of course, a sure and immediately effective method of eliminating undesirable trees, but for all except the smallest trees it has two serious disadvantages. In the first place, it may be difficult or impossible to fell a large-crowned, branchy, stiff-limbed wolf tree without causing damage to the very trees that it is desired to release. Large oaks (especially post oaks, which usually have wide crowns composed of many long, stiff, almost horizontal limbs) are generally more difficult to fell without causing damage than are red and black gums, which tend to have narrower crowns of less rigid branches. A second disadvantage, and one that is greatly accentuated on large-scale operations, is that felling is the most time-consuming and expensive of the three basic methods. Felling takes from about 1½ to 9 times as long as girdling, depending on the diameter and species of the tree and the type of girdling. Felling a 12-inch oak, for example, takes about 7 to 9 times as long as "single-hack" or "frill" girdling, and about 1½ to 2 times as long as "notch" girdling. These ratios, moreover, do not by any means tell the full story, because at least the larger felled trees must be lopped to reduce fire hazard and maintain the accessibility of the stand. The lopping will often take even longer than the felling.

The disadvantages of felling become more pronounced as the size of the tree increases, and for small trees up to, say, 3 to 5 inches in diameter at breast height are not important. Small trees can usually be felled without causing damage, and the slight disadvantage of somewhat greater cost is offset by the certainty of removing the crown competition and by the reduction of the fire hazard caused by leaving a tree on the ground rather than a standing dead tree. Trees larger than 3 to 5 inches in diameter at breast height should be felled rather than girdled, however, if they are so defective, deeply fire-scarred, or leaning that they are likely to break or blow over soon after girdling.

A possible disadvantage of felling small trees is that they may sprout vigorously. If sprouts will be even less desirable than the existing small trees, it will be best, before taking any action, to consider carefully the respective merits, with regard to sprouting, of felling as compared with girdling, poisoning, and a postponement of any treatment whatever. As a matter of fact, the usually abundant and vigorous sprouting from small hardwoods that have been either felled, girdled, or poisoned indicates that none of these treatments are advisable for releasing small pines or desirable hardwoods (say less than about 5 feet high) from the competition of small undesirable hardwoods. The sprouts resulting from any of these treatments are likely to be much more injurious to the desirable small trees than were the original hardwoods. Of course, one or more follow-up treatments could be made to release again all desirable trees affected by sprouts, but unless such follow-up treatments are practicable, fully justified ,and actually planned, treatment is better omitted in the first place.

An important exception to this last statement must often be made in the case of small longleaf pine seedlings, less than about 4 or 5 feet high, overtopped by scrub oaks which are less than about 8 inches in diameter at breast height. Here, consideration of the general difficulty of securing adequate longleaf reproduction, and of the usual delay that precedes any appreciable height growth of longleaf seedlings, is likely to result in unusually great efforts to release and preserve the existing seedling stand--even though repeated treatments are necessary. The treatment most likely to be successful under these circumstances involves cutting off the hardwoods as close to the ground as possible, and returning to cut the sprouts close to the ground as often as necessary to prevent injury to the desirable trees. The sprouting from high stumps of small hardwoods is usually more abundant and reaches a greater height than the sprouts from stumps cut very close to the ground. Sprouts usually develop freely along the full length and at the top of high stumps of small hardwoods.

Partial felling, or cutting the tree almost but not entirely through and then bending it over at the cut, away from the tree to be released, is often recommended for the reduction of sprouting from small hardwoods. As actually observed in several stands of scrubby oaks in the South, this method reduces the sprouting very little, although there are situations where the method appears to have advantages. For example, consider a pine 3 feet high and overtopped by a large-crowned scrub oak 3 inches in diameter at breast height and 2 feet away. If the oak is felled, the resultant sprouts will probably engulf the pine in a comparatively short time if no follow-up treatment is made. If the stump is cut high the sprouts will be taller and more numerous. If the oak is girdled, despite its small size, it will probably still sprout so profusely as to endanger the pine. If, however, the oak is cut partially through at about 2 feet and bent over away from the pine, the overhead crown competition will be removed and the sprouting, while not eliminated, may be reduced sufficiently to make further release treatments unnecessary. The crowns of bent-over hardwoods may live and apparently flourish for years in a horizontal position. A disadvantage that may often be serious is that the tops constitute a considerable obstruction to fire control.

Lopping is another method of disposing of the crown competition of very small hardwoods. This consists of lopping the top of the undesirable tree at a point several feet below the level of the top of the desirable tree that is to be liberated. It is claimed that this method will effectively and economically reduce both crown competition and sprouting. It is applicable, however, only to very small trees, the crowns of which extend almost or entirely to the ground, and the work may be entirely wasted if the lopped top quickly grows back to a position that crowds the tree that it was intended to release.

GIRDLING

METHODS

Girdling consists of cutting a complete ring of hacks or chips around a tree. To be effective, the girdle or ring must be absolutely complete or continuous and must extend through the bark and usually at least one-half inch into the sapwood. It may be made at any convenient height, since its object is merely to sever and part the vertical strands of cambium or inner bark which comprise the actively growing portion of a living tree trunk. There are several types or methods of girdling, of which the simplest is to make a ring of single, overlapping, downward-slanting hacks with an ax.

This is known as "single-hacking", "frilling", or "ring-girdling." "Double-hacking", or "chip-girdling", consists of making two rings of downward-slanting ax hacks, the second about 2 to 6 inches above the first and resulting in the removal of chips. "Notching" or "notch-girdling" involves the formation of a V-shaped notch by making both downward- and upward-slanting strokes with an ax. "Peeling" or "banding" consists of removing a band of bark 6 inches to 2 or 3 feet wide and can be easily accomplished only during the relatively short period in the spring when the bark may be readily peeled. These various types of girdling are all made with an ax, but other tools may also be used. A paper and pulp company in Canada has found a chain saw more effective and cheaper than an ax, and recent studies by the Lake States Forest Experiment Station have shown that for small pin cherry (up to 7 inches in diameter) either a draw knife or a chain saw is cheaper than an ax. The tool most commonly used, however, is the double-bitted ax. Its greater general utility doubtless accounts in large part for its use in preference to more specialized tools, but lack of knowledge and experience concerning the other tools is also an important factor.

The more elaborate and hence more costly methods of girdling are more certain to be effective because the completeness of the girdle can be easily and quickly checked, and because the comparatively wide gap made in the cambium makes it impossible for most trees to bridge the girdle with callous growth. The simpler and cheaper methods are difficult to supervise and inspect. Unless the men doing the girdling are unusually efficient or conscientious, or the particular species are very easy to kill, it is quite possible that a large percentage of the girdled trees may not be killed at all. In general, "double-hacking" or "chip-girdling" offers the best combination of cheapness and effectiveness. With any form of girdling, it is especially necessary to girdle carefully around deep fire scars or other cavities. The living tissues at the edges of such cavities are often curved deeply inward and are difficult to cut through completely. If it is impossible to cut these tissues within a cavity, the girdle should be cut either *around* the cavity, outlining it with a complete, continuous series of cuts, or completely *above* the cavity. Hardwoods that are relatively difficult to kill by girdling (especially black gum, red or sweet gum, and elms) should be girdled at least 2 inches into the sapwood.

LABOR COSTS

The labor cost of girdling in stand-improvement work naturally varies greatly with the tool, the method, the species (whether hard- or soft-textured), the number of trees per acre, the topography, and the efficiency of the labor. Thus "average" costs are subject to considerable variation. However, certain basic averages can be given and examples from actual operations have considerable value. For "frilling", it takes about 0.4 minute for a 6-inch tree, 0.6 minute for a 10-inch tree, 0.8 minute for a 14-inch tree, and 1.0 minute for an 18-inch tree. For "double-hacking", these figures are approximately doubled; and for "notching", these figures are increased about 4 or 5 times. Actual stand-improvement operations in the South, under widely varying conditions, generally average between 0.2 and 0.8 acre per man-hour, or 1.25 to 5 man-hours per acre.

RESULTS

Granted that a hardwood is completely girdled, how soon will it die, how and when will it fall, what damage will it do in falling, and how much will it sprout? Answers to these questions were obtained from studies made (1) in cut-over stands of shortleaf pine and mixed hardwoods on the Ouachita National Forest, Ark., between 1929 and 1934, and (2) in cut-over stands of loblolly and shortleaf pines and mixed hardwoods at Urania, La., between 1933 and 1935 (not yet finished).

In the course of three seasons (October 1929, July 1930, and May 1931) on the Ouachita National Forest, 333 undesirable hardwoods of 10 very common species were girdled by single-hacking or frilling. The 10 species were northern red oak,[1] southern red oak,[2] black oak,[3] and blackjack oak[4] (all in the botanical group of black oaks), white oak[5] and post oak[6] (in the group of white oaks), mockernut hickory,[7] black hickory,[8] black gum,[9] and winged elm,[10] but only the 6 oaks and 2 hickories were adequately represented. The girdled trees ranged from 4 to 23 inches in diameter at breast height. A few trees were incompletely girdled and were still living 5 years after treatment, but the discussion below is concerned only with the trees that were completely girdled. As an indication of the efficiency of the work, carried on with ordinary local labor, only 11 trees, or 3 percent, were later noted as incompletely girdled (although others may actually have been incompletely girdled but died anyway).

In the Urania study, 35 undesirable hardwoods of 8 species were girdled by double-hacking or chip-girdling in February 1933, and 118 undesirable hardwoods of 10 species were girdled with notches in April 1933. The trees ranged from 10 to 31 inches in diameter at breast height, and post oak,[6] red gum,[11] and black gum[9] were the most common species. Only 2 trees, or 1.3 percent, were incompletely girdled. The results given below apply only to the period of 2 years that has elapsed to date; the study will continue until all of the girdled trees have fallen.

Mortality

OUACHITA STUDY.--Omitting for the moment the 5 black gums in the study, all of the 180 trees girdled in October 1929, all of the 97 trees girdled in July 1930, and all of the 40 trees girdled in May 1931 were dead in November 1934, i.e., after periods of 5, 4-1/3, and 3-1/2 years, respectively. Of the 5 black gums girdled in October 1929, 3 were still living in November 1934.

Again omitting the black gums, the following rates of mortality were observed: Nine months after the October 1929 girdling, 69 percent of the trees were dead; 10 months after the July 1930 girdling, 80 percent of the trees were dead; and 19 months after the October 1929 girdling, 89 percent of the trees were dead.

The group of black oaks, exclusive of blackjack oak, succumbed the most quickly; all were dead 9 months after the October 1929 girdling and 10 months after the July 1930 girdling. Blackjack oak was also killed rather quickly; 66 percent were dead in 9 months, and 93 percent in 19 months, after the October 1929 girdling. The white and post oaks and the hickories reacted similarly to the October 1929 girdling; only 38 and 37 percents were dead in 9 months, and 76 and 80 percents were dead in 19 months, respectively. Ten months after the July 1930 girdling, however, 86 percent of the white and post oaks, but only 35 percent of the hickories, were dead.

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[1] Quercus borealis maxima (Marsh.) Ashe

[2] Quercus rubra L.

[3] Quercus velutina La Marck

[4] Quercus marilandica Muench.

[5] Quercus alba L.

[6] Quercus stellata Wang.

[7] Hicoria alba (L.) Britt.

[8] Hicoria buckleyi arkansana (Sarg.) Ashe

[9] Nyssa sylvatica Marsh.

[10] Ulmus alata Michx.

[11] Liquidambar styraciflua L.

URANIA STUDY.--Omitting 11 trees, or 7 percent, that fell while being girdled (due to being hollow, very rotten, or deeply scarred), and also omitting the 2 incompletely girdled trees, 87 percent of the 32 hardwoods girdled in February 1933 and 97 percent of the 108 hardwoods girdled in April 1933 were dead in June 1935. For the February (double-hacked) group, the mortality by species was: Oaks, 100 percent; red gum, 70 percent; and black gum, 67 percent. For the April (notched) group, the corresponding mortality was: Oaks, 100 percent; red gum, 92 percent; and black gum, 95 percent. Thus only the gums were still living in June 1935, but considering the length of the period and the high percentages the results even for these species are eminently satisfactory. Six months after the April notch-girdling, 57 percent of all the trees were dead, and at 13 months, 71 percent were dead. Fifteen months after the February double-hack girdling, however, only 16 percent of all the trees were dead. If the month of treatment has had no significant effect, these figures show that the double-hacked girdles result in a slower rate of mortality than for the notched girdles. The total mortality at about 2 years, however, is not appreciably less for the double hacks than for the notches. The eventual mortality will presumably be 100 percent for both methods. The living gums had unhealthy foliage in 1935 and will probably die within the next year or two.

The group of black or red oaks (excluding willow oak) succumbed the most quickly; willow oak, post oak, and white oak ranked next; and red gum and black gum were the slowest to die. Of the April (notch) girdling, all of the black oak group, only 8 percent of the red gums, and none of the black gums, were dead 1 month after treatment. Even 13 months after treatment only 54 percent of the red gums and 26 percent of the black gums were dead. Of the February (double-hack) girdling, 75 percent of the group of black oaks, but none of the red or black gums, were dead 15 months after treatment.

Rate of fall

OUACHITA STUDY.--Standing dead trees constitute a high fire hazard, hence the interest in knowing the rate of fall of girdled trees. Data on this phase of girdling are presented in table 1, which shows for various periods, diameter classes, and species in the Ouachita study the percentages of dead girdled trees that were in the zero- to 8-foot height class. This height class includes trees that had been uprooted, broken at the ground level or girdle, or consisted of a stub or snag less than 8 feet high, and thus represents trees that are actually or essentially "down." The group of black oaks and the hickories showed very similar rates of fall and were, therefore, grouped together. The table shows that the girdled black oaks and hickories fall at a considerably faster rate than do the white oaks. The rate of fall increases more or less with decrease in diameter and with increase in the period since girdling, but the relationships are by no means as clear-cut as might be expected.

Inasmuch as table 1 shows that for certain species and sizes only a relatively small percentage of the girdled trees were in the zero- to 8-foot height class 5 years after girdling, the condition of snags over 8 feet high is of interest. If they retain their larger limbs until the entire snag falls, both the fire hazard and the danger of damage to small pine seedlings and saplings are increased. Observations and actual counts of the number of remaining limbs over 5 inches in diameter, however, showed that the girdled trees generally dropped their larger limbs piecemeal and that most of the taller snags still standing 5 years after girdling were almost or entirely devoid of large limbs.

TABLE 1. -- *Percentage of girdled trees in the zero- to 8-foot height class in November 1934, by periods, diameter classes, and species groups. Ouachita National Forest, Ark.*

Tree diameter at breast height	Black oaks[1] and hickories[2]		White oaks[3]		Total	
	Trees girdled	Number in zero- to 8-foot height class in 1934	Trees girdled	Number in zero- to 8-foot height class in 1934	Trees girdled	Number in zero- to 8-foot height class in 1934
Inches	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
5 years after girdling in October 1929:						
4 - 7	75	76	21	52	96	70
8 - 11	35	40	6	33	41	39
12 - 23	26	31	15	20	41	27
4-1/3 years after girdling in July 1930:						
4 - 7	22	55	25	24	47	38
8 - 11	17	53	32	22	49	33
3-1/2 years after girdling in May 1931:						
4 - 7	11	64	10	0	21	33
8 - 11	10	60	9	0	19	32
Total, all three periods:						
4 - 7	108	70	56	30	164	57
8 - 11	62	47	47	19	109	35
12 - 23	26	31	15	20	41	27

[1] Includes black, northern red, southern red, and blackjack oaks.

[2] Includes mockernut and black hickories.

[3] Includes white and post oaks.

URANIA STUDY.--Twelve percent of all the hardwoods notched in April 1933 fell within the first 6 months, 19 percent were down after 13 months, and 35 percent were down after 26 months. These percentages are higher than should be considered typical for the method, since many of the notches were cut unnecessarily wide and deep by inexperienced men. There was a large variation according to species. At 6 months, 25 percent of the red gums, 9 percent of the oaks, and none of the black gums had fallen. At 26 months, 67 percent of the red gums, 21 percent of the oaks, and 18 percent of the black gums had fallen.

Of the hardwoods double-hacked in February 1933, none had fallen 28 months after treatment. This is a strikingly different result from that secured by notching, even allowing for the fact that the latter percentages are higher than would normally be expected.

OUACHITA STUDY.--One of the reasons for girdling rather than felling is to protect a desirable young stand in an understory from injury by falling trunks and crowns. It is possible, however, that girdled trees may cause as much or even more injury of this nature by their haphazard blowing over or breaking. The sprouts from girdled trees may, also, conceivably cause more injury to desirable reproduction than the ungirdled trees. Thus the actual damage done by girdled trees is of considerable interest.

In the Ouachita study, only 10 percent of the girdled trees injured pine seedlings or saplings by reason of part or all of the deadened tree falling on or against the small pines. An additional 6 percent of the girdled trees produced sprouts that severely suppressed small pine seedlings. Considering the large number of small pines on the experimental area, the number actually damaged by falling trees or limbs, or by sprouts, was very small indeed.

It was not possible to compute the percentage of the total number of small pines damaged, but suffice it to say that the percentage was evidently very small. In fact, at the time of the last examination, 5 years after girdling, it was frequently noted that falling limbs and trees had just barely missed hitting vigorous young shortleaf pines. These small pines are very resilient and flexible, and the falling limbs and trees were for the most part very unsound. These two factors undoubtedly helped to protect many young pines from injury when struck glancing blows by such falling limbs or trees. The damage from this source probably cannot be eliminated, yet it is satisfactorily small and by no means a serious disadvantage of girdling.

The damage caused by sprouts, however, can be largely eliminated by not girdling trees of species and sizes that are likely to sprout prolifically, and which stand directly over pines small enough to be suppressed easily by sprouts. It is usually advisable, for example, not to girdle small hardwoods standing directly over pine seedlings less than about 5 feet high. Small pine seedlings in this position will undoubtedly be retarded in growth, and some or many may die before reaching a height great enough to warrant the girdling of the trees above them. The vigorous sprout growth that may result from girdling small hardwoods, however, is much more likely not only to kill small pines but also to make further pine reproduction more difficult or impossible. Small hardwoods also serve to a greater or less extent as "nurse trees" for small pine seedlings and as "trainers" to keep the pines straight and well pruned; their undesirable competition with these pines is more or less counterbalanced by the desirable protective cover and influence on quality that they provide.

URANIA STUDY.--Twenty-three percent of the trees that have fallen to date have caused some damage to small pines. Although this may seem a rather high figure, the actual damage has been very slight and damage to individual small pines is frequently either of no practical consequence or actually a benefit to the stand as a whole. Probably not over 10 percent of the falling trees have really damaged anything of value in the stand, and this is far outweighed by the general release and liberation of previously suppressed pines. For the most part, the girdled trees are falling apart piecemeal in a very satisfactory manner and, to date, falling limbs have apparently caused no damage whatever.

Sprouting

OUACHITA STUDY.--The sprouting of dead-crowned girdled trees is related to the size of the tree, the species, the season of treatment, and the period since treatment--to mention only four of the more important factors. The influence of each of these factors may be observed in table 2, where it is evident (1) that sprouting decreases steadily with increase in diameter at breast height and is negligible beyond about 11 inches, (2) that the group of black oaks sprouts more than either the group of white oaks or the hickories, which behave alike, and (3) that the trees girdled in October sprouted most, and in May sprouted least, with July intermediate. Table 2 also appears to indicate that sprouting increases with increase in the period since treatment, but more detailed analyses using the data from intermediate examinations show that the period since treatment actually had very little effect on the percentage of trees sprouting.

TABLE 2. -- *Percentage of dead girdled trees with living sprouts in November 1934, by periods, diameter classes, and species groups. Ouachita National Forest, Ark.*

Tree diameter at breast height	Black oaks [1]		White oaks [2]		Hickories [3]		Total	
	Trees girdled	Number with sprouts	Trees girdled	Number with sprouts	Trees girdled	Number with sprouts	Trees girdled	Number with sprouts
Inches	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
5 years after girdling in October 1929:								
4 - 7	53	81	21	81	22	64	96	77
8 - 11	27	56	6	17	8	25	41	44
12 - 15	12	0	6	0	-	-	18	0
16 - 23	14	21	9	0	-	-	23	13
4-1/3 years after girdling in July 1930:								
4 - 7	5	60	25	44	17	53	47	49
8 - 11	14	36	32	16	3	0	49	20
3-1/2 years after girdling in May 1931:								
4 - 7	5	20	10	20	6	0	21	14
8 - 11	7	14	9	0	3	0	19	5
Total, all three periods:								
4 - 7	63	75	56	54	45	51	164	61
8 - 11	48	44	47	13	14	14	109	27
12 - 15	12	0	6	0	-	-	18	0
16 - 23	14	21	9	0	-	-	23	13

[1] Includes black, northern red, southern red, and blackjack oaks.

[2] Includes white and post oaks.

[3] Includes mockernut and black hickories.

The average number and size of sprouts from sprouting girdled trees in the Ouachita study did not vary appreciably or consistently with species or season of treatment. The relationship to the size of the tree is shown in table 3 for all species girdled in October 1929 and examined in November 1934.

TABLE 3. -- *Data on living sprouts in November 1934, from trees girdled in October 1929. Ouachita National Forest, Ark.*

Tree diameter at breast height	Basis: Number of trees sprouting	Average number of sprouts per tree	Average height of tallest sprout per tree	Average greatest width of entire sprout clump per tree
Inches			*Feet*	*Feet*
4 - 7	75	4.9	8.0	6.4
8 - 11	18	4.0	7.1	6.3
12 - 15	0	-	-	-
16 - 19	3	2.0	6.0	4.3

URANIA STUDY.--The girdled hardwoods in the Urania study were all 10 inches or more in diameter at breast height and their sprouting in the first 2 years since treatment has been negligible. Indeed, the sprouts have been so few, so small, and so utterly without significance with respect to the liberated small pines (most of which are well over 1 inch in diameter at breast height), that no counts or measurements have been made or are contemplated.

POISONING

METHODS OF APPLICATION

Poisoning consists of the application or injection of a chemical destructive to plant life. There are several methods of application or injection into trees, of which the more common are (1) to swab or pour the poison into a complete girdle or "frill" around the tree, (2) to swab or pour the poison into one or more unconnected hacks, (3) to swab the poison on a completely peeled section of the bole, (4) to pour the poison into auger holes bored into the bole, and (5) to spray the poison on the foliage. A number of different investigators in the United States and in India have shown that the first method is by far the most effective, and usually the only thoroughly effective method of application. The poisoning of one or more unconnected hacks was found to be ineffective in the poisoning experiments made on the Ouachita National Forest, Ark., between 1929 and 1934, the results of which will be given in some detail below. The lateral spread of a poison from the point of application or injection is negligible. Application of poisons to single ax-hacks in the Ouachita study, for example, killed vertical strips of tissue extending some distance above and below the hacks, but essentially no wider than the hacks. The crown as a whole continued to live in a large proportion of the trees so treated.

As a modification of the first method given above, poisoning tools have been devised by Cope and Spaeth and by MacKinney (see references under "III. Poisoning" in the appended bibliography) to reduce the cost of poisoning trees by making it a 1-man rather than a 2-man operation. In both tools the poisonous solution is stored in the long, tubular handle of an implement with a chisel-like cutting edge, and the solution is injected immediately into each incision made by jabbing the blade through the bark and about one-half inch into the sapwood.

POISONS

A large number of different chemicals have been tested for their tree-killing qualities. In the 1929-34 Ouachita study, 15 different chemicals or mixtures of chemicals were tested. In general, arsenicals have been most widely used. Commercial white arsenic in particular has been widely used and has usually been found to be very effective, either in a water solution or mixed with lye in a water solution. Different proportions of white arsenic, lye, and water have been used successfully by several different investigators, so that the arsenic is evidently toxic to trees over a fairly wide range of dilution. Expressed in pounds of white arsenic, pounds of lye, and gallons of water, respectively, effective formulae include the following: 1-1/2-4, 1-1-4, 1-1-2, 1-2-2, 1-0-1, 2-1/2-1 and 4-1-3/8. Regardless of the formula employed, the solution must be prepared and handled very carefully because white arsenic is *very poisonous* and gives off poisonous fumes when in a boiling solution. Indeed, no poisons, and espesially none with an arsenic or chlorate base, should be used without first obtaining specific directions for their proper preparation and handling, and, second, observing specific precautions in their application. Arsenic and many other chemicals are poisonous to cattle and other livestock, so that their use should be limited to stands either not frequented by stock or closed to stock for at least 3 weeks. Among other substances that have been found to be effective in killing trees and shrubs, the following may be mentioned as representative: Sodium and calcium chlorate; potassium chromate and bichromate; copper and iron sulphate; copper, sodium, barium, and zinc chloride; ammonium thiocyanate; formaldehyde; carbolic acid; sodium fluoride; ethylene oxide; cresylic acid; kerosene; and creosote. Different investigators using the same poison have frequently obtained different results, and the results of any one investigator with any one poison frequently show a variability that makes it difficult or impossible to draw specific conclusions. Consequently there is no single "best" poison for killing trees.

COSTS

Since a tree must be completely girdled before the application of a poison will prove thoroughly effective, the cost of poisoning is equal to the cost of girdling ("frilling" will do), plus the cost of preparing and applying the poison. The total cost of poisoning is therefore even more difficult to pin down to reliable "average" values than is the cost of girdling alone, but in general the total cost of poisoning in complete girdles has been found to be from 1.2 to 3 times more expensive than simple girdling. The use of special poisoning tools, such as those described above may materially reduce the cost of poisoning-- especially in brushy stands where "frilling" with an ax is relatively difficult.

RESULTS

With poisoning, as with simple girdling, the principal questions to be answered are: How soon will the trees die, how and when will they fall, what damage will they do in falling, and how much will they sprout? Answers were obtained from the 1929-34 Ouachita study, mentioned above. In the course of three seasons (October 1929, July 1930, and May 1931), 1,355 hardwoods of the same 10 species that were simply girdled (see above under *Girdling: Results*) were completely girdled by "frilling" and one or another of 15 poisonous solutions was poured into the girdles. Most of the conclusions will be drawn from the two largest-scale treatments: a white arsenic and lye treatment applied to 222 trees, and a commercial weed-killer (largely calcium chlorate) applied to 219 trees.

Mortality

Omitting 12 living trees that had been incompletely girdled through carelessness, only 1 of 1,343 trees poisoned in October 1929, July 1930, and May 1931 was still living in November 1934. Sixteen black gums are included in the number treated.

The rate of mortality of completely girdled, poisoned trees varied with the poison and with the species. Combining all species, the following rates were observed: Nine months after the October 1929 poisoning, 97 percent of the 222 arsenite-poisoned trees, 61 percent of the 219 chlorate-poisoned trees, and 79 percent of the 151 miscellaneous-poisoned trees were dead. Nineteen months after the October 1929 poisoning, 97 percent of the arsenite-poisoned trees, 86 percent of the chlorate-poisoned trees, and 98 percent of the miscellaneous-poisoned trees were dead. Of the 8 miscellaneous poisons in these tests, copper sulphate, ferric sulphate, and a sodium arsenite-sodium chloride-potassium nitrate mixture killed the trees most rapidly, and creosote and crude carbolic acid killed the trees most gradually. Ten months after the July 1930 poisoning, 99 percent of 100 arsenite-poisoned trees, 82 percent of each of 100 sodium chlorate-poisoned and 99 zinc meta-arsenite-poisoned trees, and 76 percent of 98 copper sulphate-poisoned trees were dead. Except for the sodium arsenite, copper sulphate, and ferric sulphate treatments, the poisoned trees did not die appreciably, if at all, more quickly than the merely girdled trees.

The group of black oaks, exclusive of blackjack oak, succumbed most quickly to poisoning: 98 percent were dead 9 months after the October 1929 treatment, and 99 percent were dead 10 months after the July 1930 treatment. Blackjack oak was also killed rather quickly by poisoning: 86 percent were dead in 9 months, and 96 percent in 19 months after the October 1929 treatment. The white and post oaks ranked next: 77 percent were dead in 9 months, and 97 percent in 19 months after the October 1929 treatment; and 87 percent were dead 10 months after the July 1930 treatment. Of the hickories, 56 percent were dead in 9 months, and 82 percent in 19 months after the October 1929 treatment; and 64 percent were dead 10 months after the July 1930 treatment. The black gums were the slowest to succumb to poisoning; only 19 percent were dead in 9 months and 50 percent in 19 months after the October 1929 treatment. Although some poisons killed all species sooner than simple girdling, the relative resistance of the different species to poisoning was practically the same as their relative resistance to simple girdling.

Rate of fall

Data on this phase of poisoning are presented in table 4, which shows for various poisons, periods, diameter classes, and species in the Ouachita study the percentages of dead poisoned trees that were in the zero- to 8-foot height class, i.e., that were actually or essentially "down." The group of black oaks and the hickories were grouped together because of their similar rates of fall, and the relationship between this group and the white and post oaks is essentially the same as shown in table 1 for merely girdled trees. Black oaks and hickories fall at a considerably faster rate than do white oaks, and the rate of fall of either group generally increases with decrease in diameter and with increase in the period since poisoning. There is a considerable difference between the rates of fall for the two poisons tested on the largest scale, sodium arsenite and calcium chlorate. The arsenite-poisoned trees fell at a slower rate than did the chlorate-poisoned trees, and in general the former group fell at the same or a slower rate, and the latter group at a faster rate, than did the merely girdled trees. Taking the averages for all treatments shown in table 4, poisoned trees evidently fall at about the same rate as merely girdled trees (table 1),

TABLE 4. -- *Percentage of poisoned trees in the zero- to 8-foot height class in November 1934, by poisons, periods, diameter classes, and species groups. Ouachita National Forest, Ark.*

Poison applied to complete girdles	Tree diameter at breast height	Black oaks[1] and hickories[2]		White oaks[3]		Total	
		Trees girdled	Number in zero- to 8-ft. hgt. class in 1934	Trees girdled	Number in zero- to 8-ft. hgt. class in 1934	Trees girdled	Number in zero- to 8-ft. hgt. class in 1934
	Inches	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
5 years after poisoning in October 1929:							
Sodium arsenite[4]	4 - 7	95	61	38	32	133	53
	8 - 11	34	53	13	0	47	38
	12 - 23	20	40	13	15	33	30
Calcium chlorate[5]	4 - 7	92	84	25	72	117	81
	8 - 11	35	63	8	75	43	65
	12 - 23	29	38	8	37	37	38
4-1/3 years after poisoning in July 1930:							
Sodium arsenite	4 - 7	22	59	27	18	49	37
	8 - 11	18	33	33	9	51	18
Sodium chlorate (33% solution)	4 - 7	21	71	27	37	48	52
	8 - 11	18	50	33	24	51	33
Copper sulphate	4 - 7	24	54	22	23	46	39
	8 - 11	17	24	33	12	50	16
Zinc meta-arsenite	4 - 7	23	48	25	16	48	31
	8 - 11	16	44	34	6	50	18
3-1/2 years after poisoning in May 1931:							
Sodium arsenite	4 - 7	11	73	10	10	21	43
	8 - 11	11	36	7	14	18	28
Sodium chlorate (33% solution)	4 - 7	11	73	10	70	21	71
	8 - 11	10	30	9	11	19	21
Copper sulphate	4 - 7	13	69	11	36	24	54
	8 - 11	8	75	7	14	15	47
Zinc meta-arsenite	4 - 7	10	70	10	20	20	45
	8 - 11	11	27	9	11	20	20
Kerosene	4 - 7	11	64	8	25	19	47
	8 - 11	11	45	10	10	21	29
Total	4 - 7	333	68	213	33	546	54
	8 - 11	189	46	196	14	385	30
	12 - 23	49	39	21	24	70	34

[1] Includes black, northern red, southern red, and blackjack oaks.

[2] Includes mockernut and black hickories.

[3] Includes white and post oaks.

[4] One lb. commercial white arsenic to 1 lb. sodium hydroxide to 4 gals. water.

[5] Two lbs. commercial weed-killer to 1 gal. water.

TABLE 6. *Percentage of dead poisoned trees with living sprouts in November 1934 by poisons, periods, diameter classes, and species groups. Ouachita National Forest, Ark.*

Poison applied to complete girdles	Tree diameter at breast height	Black oaks[1]		White oaks[2]		Hickories[3]		Total	
		Trees poisoned	Number with sprouts	Trees poisoned	Number with sprouts	Trees poisoned	Number with sprouts	Trees poisoned	Number with sprouts
	Inches	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
5 years after poisoning in October 1929:									
Sodium arsenite[4]	4 - 7	66	86	38	63	29	83	133	79
	8 - 11	31	35	13	31	3	0	47	32
	12 - 15	14	7	9	11	1	0	24	8
	16 - 23	5	20	4	0	-	-	9	11
Calcium chlorate[5]	4 - 7	42	71	25	44	51	53	118	58
	8 - 11	29	34	8	12	6	50	43	33
	12 - 15	21	19	4	0	-	-	25	16
	16 - 23	8	0	4	0	-	-	12	0
4-1/3 years after poisoning in July 1930:									
Sodium arsenite	4 - 7	4	100	27	48	18	61	49	57
	8 - 11	14	36	33	6	4	25	51	16
Sodium chlorate (33% solution)	4 - 7	4	25	27	18	17	35	48	25
	8 - 11	14	14	33	21	4	25	51	20
Copper sulphate	4 - 7	6	50	22	36	18	61	46	48
	8 - 11	14	22	33	15	2	50	49	18
Zinc meta-arsenite	4 - 7	5	60	25	36	18	44	48	42
	8 - 11	13	38	34	18	3	33	50	24
3-1/2 years after poisoning in May 1931:									
Sodium arsenite	4 - 7	5	40	10	0	6	33	21	19
	8 - 11	8	0	7	14	3	0	18	6
Sodium chlorate (33% solution)	4 - 7	5	20	10	30	6	17	21	24
	8 - 11	7	14	9	0	3	0	19	5
Copper sulphate	4 - 7	6	17	11	9	7	0	24	8
	8 - 11	6	0	7	0	2	50	15	7
Zinc meta-arsenite	4 - 7	4	0	10	20	6	0	20	10
	8 - 11	8	25	9	0	3	33	20	15
Kerosene	4 - 7	5	60	8	25	6	33	19	37
	8 - 11	8	38	10	20	3	33	21	28
Total	4 - 7	152	69	213	37	182	51	547	50
	8 - 11	152	28	196	14	36	28	384	21
	12 - 15	35	14	13	8	1	0	49	12
	16 - 23	13	8	8	0	-	-	21	5

[1] Includes black, northern red, southern red, and blackjack oaks.

[2] Includes white and post oaks.

[3] Includes mockernut and black hickories.

[4] One lb. commercial white arsenic to 1 lb. sodium hydroxide to 4 gals. water.

[5] Two lbs. commercial weed-killer to 1 gal. water.

due largely to the compensating rates of arsenite- and chlorate-poisoned trees. As with the merely girdled trees, poisoned trees usually fall apart gradually and lose most or all of their large limbs before the main trunk falls.

Damage

The damage done to desirable young pines by poisoned trees falling on or against them, or by the sprouts from poisoned trees, is essentially the same as that caused by the falling or sprouting of merely girdled trees. That is to say, that a very small percentage of poisoned trees cause such damage, and that a negligible percentage of desirable seedlings and saplings are damaged. This statement is based on observations made in the Ouachita study. Since poisoned trees appear to disintegrate and fall in essentially the same manner and at the same rate as merely girdled trees, the discussion of damage caused by girdled trees applies also to poisoned trees.

Sprouting

The sprouting of dead-crowned girdled-and-poisoned trees is affected by the same factors listed for merely girdled trees. Table 5 presents representative data on the sprouting of poisoned trees in a form comparable to table 2 for merely girdled trees, and the conclusions drawn from the data are the same as for girdled trees. In comparing tables 2 and 5, it will be noted that there are no very large or consistent differences beween the percentages of sprouting trees resulting from simple girdling and from poisoning, respectively. The poisons, as a group, may show a slight net advantage, but any such advantage is too uncertain in fact and too small in amount to have any practical significance. For the same species, sizes, seasons, and periods, some poisons were slightly more effective in reducing sprouting, others slightly less effective, than simple girdling. On the basis of the Ouachita study, therefore, we must conclude that poisoning neither reduces nor increases sprouting to any appreciable extent.

The average number and size of sprouts from sprouting poisoned trees in the Ouachita study were essentially the same as those from sprouting trees that had only been girdled. A brief and representative summary, for all species poisoned on a large scale in October 1929 and examined in November 1934, is presented in table 6.

TABLE 6. -- *Data on living sprouts in November 1934 from trees poisoned in October 1929. Ouachita National Forest, Ark.*

Tree diameter at breast height	Basis: Number of trees sprouting		Average number of sprouts per tree		Average height of tallest sprout per tree		Average width of entire sprout clump per tree	
	Treated with sodium arsenite	Treated with calcium chlorate	Treated with sodium arsenite	Treated with calcium chlorate	Treated with sodium arsenite	Treated with calcium chlorate	Treated with sodium arsenite	Treated with calcium chlorate
Inches					*Feet*			
4 - 7	106	71	4.7	3.7	7.4	7.1	5.4	5.1
8 - 11	16	17	2.6	2.6	6.6	7.2	5.1	5.0
12 - 15	2	4	2.5	3.7	5.0	6.7	3.5	2.7

In comparing table 6 with table 3, it will be noted that the poisoned sprouting trees have somewhat fewer and somewhat smaller sprouts than have the merely girdled trees. The differences, however, are very small and are thought to be of no practical significance in ordinary stand-improvement work.

POISONING VERSUS GIRDLING

A comparison of the respective merits of poisoning and girdling is readily made by listing the various possible reasons for poisoning rather than merely girdling, and by considering the merits of each separately. The reasons and their merits are as follows:

1. - TO KILL TREES QUICKLY RATHER THAN OVER A PERIOD OF SEVERAL MONTHS OR YEARS. This reason should be sufficient to justify poisoning if the trees to be killed are rapidly spreading a virulent disease, or will--within a year or two--shade out or irreparably deform or stunt desirable trees beneath them. Neither of these conditions is ordinarily a factor in stand-improvement work in southern forests. Provided that the undesirable trees die within, say, 3 or 4 years at the most (and large percentages of girdled trees die in 1 or 2 years), it usually makes little practical difference just when they die. Indeed, a delayed mortality is often considered to be preferable since the stand is then opened up more gradually and the released desirable trees can gradually adjust themselves to the new conditions.

2. - TO PREVENT OR GREATLY REDUCE SPROUTING. This reason would justify poisoning (1) if poisoning would actually prevent or greatly reduce sprouting, (2) if the trees to be killed were of a size and species that usually sprout vigorously and prolifically after girdling, and (3) if such sprouting would suppress or seriously interfere with desirable reproduction either already present or expected. With reference to the first qualification, there is some evidence that certain poisons applied at certain seasons will greatly reduce sprouting, but poisons as a group do not appear to reduce sprouting below that resulting from simple girdling. The second qualification or condition often obtains in southern forests, but the third is not usually an important factor. If sprouts will do more damage than the original trees, it is likely that stand improvement should be postponed several years until the reproduction is beyond the reach of ordinary sprouting, and that stand improvement is not an immediate necessity. Ordinarily, some damage from sprouts can be expected and can be tolerated without constituting a serious drawback to the stand-improvement operation as a whole.

3. - TO KILL TREES MORE CHEAPLY. Since numerous experiments have indicated that poisons are not thoroughly effective unless applied to a continuous girdle, and since (so far as known) a continuous "chip" or "notch" girdle alone will sooner or later kill all individuals of all southern hardwood species, effective poisoning is necessarily more expensive, not cheaper, than simple girdling. Poisoning would be cheaper only if the application of poisons to a few bored augerholes, one or several isolated hacks, or the like, were effective. No such methods are known to be satisfactorily or consistently effective.

4. - TO KILL TREES THAT SURVIVE GIRDLING. Certain southern hardwoods, notably red or sweet gum and black gum, are relatively difficult to kill (at least within 2 or 3 years) by simple girdling. How or why these species some-

times survive apparently complete girdling for at least 5 years is not definitely known, nor is it certain how long a completely girdled, previously sound tree of these species can live. This would be a good reason for poisoning such species but for the facts (1) that red and black gums usually comprise only a part (and frequently only a very small part) of the stand that is to be killed, (2) that many trees (and occasionally a very high percentage) of these species do succumb relatively quickly to simple girdling, (3) that many individuals that do not die directly as a result of simple girdling are soon blown over, breaking at the girdle due to the weakening caused by rot and the removal of mechanical support, and (4) that girdled trees, even though living, provide much less competition to neighboring trees than do ungirdled trees. In other words, the fact that simple girdling is relatively ineffective on certain species will usually be an insufficient reason for taking the trouble to poison them in the course of extensive stand improvement. Locally, where red and black gums are abundant and very undesirable, and where all must certainly be killed within at least 2 or 3 years, either felling or poisoning would be a better method than merely girdling.

5. - TO HASTEN THE DECAY AND FALL OF DEADENED TREES AND THUS MORE RAPIDLY DECREASE THE FIRE HAZARD OFFERED BY RESISTANT SNAGS. The available information on this point from the Ouachita study is that hardwoods poisoned with calcium chlorate fall somewhat more rapidly than merely girdled trees, but that hardwoods poisoned with sodium arsenite fall somewhat more slowly than merely girdled trees. In either case, the differences are small and probably of little or no practical significance. Thus the common belief that trees treated with any poisonous substance disintegrate and fall more rapidly than merely girdled trees is not borne out by the Ouachita study, and poisoning cannot be considered to have any advantage over girdling in this respect. At least one investigator, however, has found that arsenic-poisoned trees rot and fall more rapidly than merely girdled trees, so in view of the conflicting evidence no positive generalized statement can be made. The fact that there is conflicting evidence implies that there is little or no real or consistent difference between poisoning and simple girdling with respect to the rotting, disintegration, and fall of treated trees.

SUMMARY AND CONCLUSIONS

The preceding discussion may be summarized very briefly as follows:

1. - Felling by cutting close to the ground, and partial felling and bending over, are the best methods for killing or removing the crown competition of small hardwoods, up to 3 to 5 inches in diameter at breast height. Because of the sprouting that will usually occur, neither method is advisable if there are no pines or more valuable hardwoods to be released, or if these more valuable trees are less than about 5 feet high.

   An important exception to the last statement must often be made in the case of longleaf pine less than about 4 or 5 feet high and overtopped by relatively small scrub oaks. Omission of treatment in such stands may result in the death of a large proportion of the longleaf seedlings. In view of the relatively long interval between good longleaf seed years, and the usual delay that precedes any appreciable height growth of longleaf seedlings, the probable high mortality in untreated stands is usually considered a sufficient reason for stand improvement. However, the only method likely to be successful in permanently releasing small longleaf pines from scrub oaks involves at least one and usually several follow-up treatments-- cutting the oaks close to the ground and returning often enough to cut back the oak sprouts as often as they reach the height of the pines.

2. - Girdling is the best method for killing larger hardwoods. A "double-hack" or "chip" girdle, exposing about a 4-inch band of sapwood, offers the best combination of effectiveness and cheapness, with ordinary labor and for all species. If, however, the workmen are unusually experienced and conscientious, "single-hacking" or "frilling", with the edges of the cuts separated by twisting the ax, is likely to be satisfactory and is cheaper.

3. - Poisoning is usually unnecessarily expensive and unjustified by any outstanding or consistent advantages.

These statements are applicable to average stand-improvement operations in the South, and the word "best" merely implies the greatest excess of advantages over disadvantages for average conditions. For the citation of exceptions, qualifications, and unusual conditions that affect the choice of methods, the main body of this paper should be consulted.

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OCCASIONAL PAPER No. 51 October 3, 1935.

SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

COLLECTING, EXTRACTING, AND MARKETING SOUTHERN PINE SEED

By

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This paper releases data gathered in current investigations of the Southern Forest ExperimentStation, and is subject to correction or modification following further investigation.

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During the 20 years from 1916 through 1935, the commerce in seed of longleaf, slash, loblolly, and shortleaf pines has grown by extremely irregular stages from practically nothing to many tons of seed each year. The importance of the South for timber production, and the launching of new forestry work in connection with the Emergency Conservation Work in 1933, make it likely that in general the demand for seed will continue or increase, but the uncertainty of markets in any one year, the variations in the seed crops themselves, and the technical processes involved in extraction require that seed collectors be well informed if they are to gather seed profitably or efficiently. Certain general information of use to collectors is summarized in this paper.

Much of the seed collecting so far carried on in the South has been done by men without special training in the work, or men collecting for one season only, and with no idea of creating a permanent business. As is usual under such circumstances, some of the seed has been poorly cleaned and of low quality, and much of it has been collected from any trees available, without thought of their possibly bad hereditary qualities. The situation offers a definite opportunity for skillful, reliable collectors and extractors who will concentrate their efforts upon cones from trees of high quality, develop sound and efficient methods of extraction, and certify the species, parentage, age, treatment, cleanness, and soundness of the seed they sell.

The southern pine seed business includes three technical steps--scouting, collecting, and extracting. It is well to scout cones before booking orders for seed, and to book orders for most of the seed to be collected before investing anything but spare time in the work. The collector who neglects these precautions faces the risk, on one hand, of accepting orders he cannot fill, and on the other, except possibly in years of scanty crops or of suddenly expanded state or federal planting, of tying up an investment in unmerchantable seed.

Cones can be collected most easily from felled trees. The disadvantages of this method, however, are that logging or other cutting is not always going on in bearing stands at the time cones are mature, and that cones from later crops cannot be collected from the same trees, no matter how desirable seed from those trees has proved to be. Collection from standing trees varies greatly in difficulty. Heavy crops of cones on longleaf and slash pine trees less than 40 or 50 feet high, with short branches and with the lowest living branches fairly near the ground, are relatively cheap to gather. Loblolly and shortleaf cones on similar trees, and cones of any species on tall trees with long, clear trunks and wide crowns, are far more expensive to knock down or pick. If seed is to be collected only from trees of the best form, it is easier to select such trees in uncut stands than on a logging operation. These points should be kept in mind while scouting for cones and estimating costs of collection. Before entering into contracts for large quantities of cones, it is well to time the picking of a few bushels and find out how long it takes and how much it costs per bushel.

SCOUTING FOR CONES

Estimates of the quantities of cones available for collection should be based on counts of cones and of trees bearing cones, taken in the course of more or less systematic scouting trips over the territory in which the collector expects to work. The large cones of longleaf and slash pines are easy to see and can be counted fairly accurately. Loblolly and shortleaf cones are much harder to see, especially on tall trees, and an accurate count is practically impossible, but, for his own protection, the collector should make sure that he can get *at least* the quantity ordered before he undertakes collection. No great harm is done if he somewhat underestimates the actual supply.

The number of cones available in an entire tract can be estimated by counting or estimating the cones on a number of quarter-acre or acre plots scattered uniformly over the area, reducing the figures to average number of bushels per acre and multiplying the number of bushels per acre by the number of acres in the tract. The more uniform the figures for the separate plots, and the greater the number of plots, the more reliable the final estimate will be. Fair estimates of the cones available on small tracts, or on the total number of trees to be cut on a given logging operation during the collecting season, may often be obtained by multiplying the total number of trees by the average yield per tree as determined by counting cones on 20, 50, or 100 trees chosen at random to give a fair sample of the stand.

TABLE 1. -- *Numbers of cones per bushel*

Species	Usual number	Extreme values observed[1]	
		Lowest	Highest
Longleaf	100	86	118
Slash	200	157	243
Loblolly	500	393	1,080
Shortleaf	2,000	1,444	2,545

[1] Cones from vigorous young trees tend to be above average size, and hence below the average number per bushel. The reverse is true for cones from very old trees.

Figure 1 shows the general appearance and relative size of the cones of the four species under discussion. Table 1 gives figures useful in converting numbers of cones to bushels.

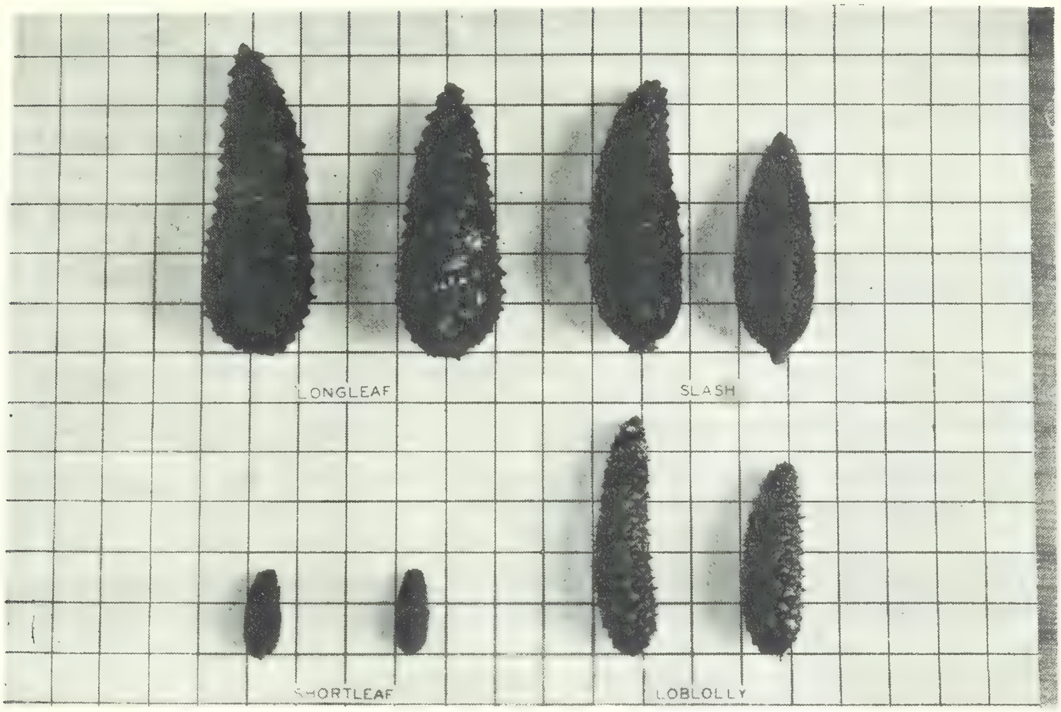

FIGURE 1. -- Cones of longleaf, slash, loblolly, and shortleaf pines photogbaphed against a background of 1-inch squares

Scouting for cones can be done as early as May or June, because cones are full size by then, and fairly easy to see. It is better, however, to scout in early August, because there is then less time between scouting and collection for drought, storms, and insects to injure the cones. In August, too, by cutting open a few cones from each of several trees, the collector can tell whether a fair percentage of the seeds contain kernels. It sometimes happens that in limited or even in extensive areas the cones contain few good seeds, while on other equally accessible areas nearby the seeds are of high quality; in such instances it is plainly to the interest of the collector to supply the better seed.

It is believed that the seeds of southern pines mature before the cones do; that is, that seed fit for use in nurseries can be extracted as early in the season as the cones can be made to open by drying. Collectors have experienced difficulty many times in the past both from gathering cones a trifle early without treating them as carefully as necessary under such conditions, and from gathering them very early and having them fail to open under any treatment. Unless the quantity of cones needed is so great that a long collecting season is essential, the safest plan is to wait until all cones have begun to turn brown, or even until the first few cones (usually those on the south sides of crowns) have begun to open. Table 2 gives, for States from Georgia and Florida to Texas, the usual dates of maturing and collection of cones and shedding of seed. Some departure from the dates given in this table may, however, be expected because of local and seasonal variations; therefore the collector should keep a sharp watch of the cones themselves.

TABLE 2. -- *Usual dates of maturity, collection, and natural opening of cones of southern pines in the states from Georgia and Florida to Texas*

Species	Maturity	Collection	Opening on trees
Longleaf	October 1 to 20	October 1 to 20	October 20 to November 10
Slash	September 1 to 10	September 1 to 20	September 20 to 30
Loblolly	September 20 to October 10	October 1 to 20	October 10 to 30
Shortleaf	October 1 to 20	October 11 to 30	November 1 on

One of the chief points to be observed in table 2 is the exceptionally early maturity of slash pine cones.

An individual or firm collecting cones on land belonging to another should obtain permission, preferably in writing, before beginning to collect.

MARKETING AGREEMENTS

First attempts at purchase or marketing of seed have sometimes led to misunderstandings, disagreements, and financial hardships. Observance of the following rules should help to eliminate such difficulties:

1. Place orders, for either cones or seed, before the earliest date of collection for the species.

2. Specify, in writing, the *maximum* quantity of cones or seed that will be accepted that season at the price agreed upon. Many a man has advertised in the papers or elsewhere for cones at so much a bushel or seed at so much a pound, without specifying any top limit to the quantity he would take, and as a result has had to purchase far more than he wanted or else incur ill feeling. Rule 2 does away with this danger. It is sometimes well, however, to include in the sales agreement an option on an additional quantity at a specified price, to be taken up or abandoned by a specified date.

3. Specify in writing the unit of measure, the price per unit, standards of quality of cones (for example, not more than 10 percent wormy cones), point of delivery, degree of shelter to be given cones until shipped or called for, and frequency of shipment or call.

In connection with rule 3, purchase by volume is preferable to purchase by weight, because of the extremely rapid loss of weight by cones during the very period at which most of them are shipped and sold. Longleaf cones collected late in September may weigh 45 pounds per bushel, those collected late in October as little as 25 pounds, and cones may lose 20 percent of their weight through unavoidable delay in delivery. It is obviously inequitable to base payment on such a changeable unit as weight, while actually the volume and the number of seeds obtainable from that volume remain the same.

COLLECTING AND SHIPPING CONES

Longleaf and slash cones are detached from the trees so easily that on logging operations the cones usually fall off when the trees hit the ground. Loblolly and shortleaf cones have to be picked from crowns of felled trees by hand; leather-palmed gloves are almost essential in picking loblolly cones because of the sharp prickles. With all four species of southern pine, collection is easiest before skidding of the logs has disarranged the tops, covered some of the cones, and made it difficult to judge the quality of individual trees.

Collection by climbing, as has been noted, is likely to be considerably more expensive than collection from felled trees, especially in the case of loblolly and shortleaf pines. It reaches its lowest cost in the case of small young trees with easily accessible crowns. There seems to be little basis for the belief, sometimes encountered, that seed from young trees is poor in quality.. Seed from young trees does sometimes include an abnormally high percentage without kernels, with an abnormally low yield of sound seed per bushel of cones as a result. This is thought to be the result of the wide spacing and consequently poor pollination of the seed bearers in young stands, rather than the actual immaturity of the trees. Such low percentages of sound seed should be revealed by scouting prior to collection. Sound seed (that is, seed with kernals) from young trees usually shows excellent germination and growth.

Light ladders are generally satisfactory for reaching the crowns of trees less than 50 feet high, but some collectors prefer climbing irons even for such trees; for larger trees, and especially for very tall ones with long, clear trunks, irons and safety belts are a necessity.

Once in the crown, the collector needs something to loosen the cones not actually within arm's reach. A bamboo pole 8 to 12 feet long, with a suitable prong or hook on one end and a thong at the other end to slip around the wrist, works well. Longleaf and slash cones are easily removed, and for these species a Y-shaped head of $\frac{1}{4}$-inch strap iron, $1\frac{3}{4}$ inches between the points, is satisfactory. For loblolly and shortleaf some sort of sharp hook should be combined with the prong.

In actual collection from either felled or standing trees, the most rapid process it is to gather the cones in bushel baskets and then pour them into sacks. Gathering directly in sacks is slow and inefficient. As the cones are tossed into the baskets, they should be freed of all trash such as pine needles, bark, and grass. If this method is used, no rehandling of single cones is necessary for either cleaning or measuring.

Except in years of great scarcity of seed, wormy cones should not be collected. They usually yield but one third to one half as much seed as sound cones, and break up badly in the tumbler and fill the seed with bits of cone scale very difficult to remove.

Cones are best shipped in sacks. Cones shipped loose are expensive to handle, and in large quantities, such as 1,000 bushels shipped in a boxcar, the lower layers become crushed and spoiled. Two-bushel sacks are generally preferred, although one-bushel sacks are easier to unload into the smaller types of extracting trays. The use of sacks of mixed sizes should be avoided if cones are being sold by volume, because they cause confusion in tallying. Sacks of loose weave are preferable to those of tight weave, which slow down the natural drying of the cones and sometimes increase the danger of mold. Fertilizer sacks should not be used. Sacks should never be sewed or fastened with wire, because pieces of wire may become mixed with the cones and ruin seed-cleaning machinery.

Cones should be shipped promptly after collection, and should at all times be given as much ventilation as possible. They should be protected from rain. The shorter the time they are left in sacks, the higher the yield of seed will be, and the better the quality of the seed.

EXTRACTING SEED

The seed can be extracted from cones of southern pines either at ordinary air temperature or by artificial heat. In both cases the principal is the same: The fairly rapid removal of water equivalent to 35 to 65 percent of the original weight of the cones, in such a manner as to cause no injury to the seed. Extraction at air temperature requires less skill and less elaborate equipment, but takes longer, requires more space, usually yields less seed, and with an occasional lot of cones may fail entirely. The difficulty with using the natural heat of direct sunshine lies in exposing the cones to full sunlight without expensive equipment or excessive handling to protect them from the heavy dews and frequent rains of the Southern States.

Extraction by artificial heat saves time and space in large operations, and ordinarily gives higher yields and possibly seed in better condition for sowing or storage. Some lots of longleaf and shortleaf pine cones, and possibly all lots of any species gathered early in the season, require a short period of "precuring" or partial drying at air temperature, to prevent their casehardening in the kiln and remaining permanently closed.

Experience has shown that no matter what the method of extraction, best results are obtained by spreading the unopened cones only one layer deep on floors, shelves, trays, or other equipment used for drying. In precuring before kiln extraction they may be spread 3 or 4 layers deep.

A bushel of unopened cones may weigh as much as 45 pounds. As a result of drying, the scales of the cones open until the bushel of cones occupies $2\frac{1}{2}$ to $3\frac{1}{2}$ times as much space as it did originally. Cones lying only one layer deep vary in their requirements for floor space or rack space per bushel, depending on the average diameter of the cones. This size in turn varies with species. Racks placed one above another must clear by a distance about equal to the length of the cones, which again varies with species. Sizes and desirable clearances of racks are given in table 3. Each unit of extracting equipment must be designed with allowance for the maximum weight of unopened cones to be loaded upon it, and for the maximum volume of the same cones after opening. In large plants the weight to be placed upon upper floors should be figured carefully, and the floor made amply strong to carry this weight. In figuring the capacity of a tumbler, it must be remembered that the tumbler must take care of about three times the volume represented by the unopened cones originally delivered at the plant.

A side-hill makes an excellent location for an extracting plant, as the cones can be delivered by truck to the upper floor or to curing sheds on or just above the same level, and, after opening, can be dumped or shoveled through a chute into the tumbler on the floor below. Details such as these increase in importance with the size of, and the investment in, the plant.

TABLE 3. -- *Effective capacities of cone trays of various sizes, and desirable clearances between trays*

Species	Capacities of trays measuring			Desirable vertical clearances between trays
	2 by 4 feet	3 by 3 feet	3 by 4 feet	
	Bushels			*Inches*
Longleaf	1.0	1.1	1.5	10
Slash	0.8	0.8	1.1	8
Loblolly	0.5	0.6	0.8	6
Shortleaf	0.4	0.4	0.6	4

Cones can be opened at air temperature on any fairly smooth, tight floor, on a rough floor covered with tarpaulins or building paper, on series of shelves, or, best of all, on tiers of wire-bottomed trays. Trays 3 by 4 feet, 2½ by 6 feet, and 4 by 5 feet have all proved convenient; the exact dimensions depend in part on the size and design of the room available. The sides of the trays may be of 1 by 3-inch pine or cypress, reinforced with angle irons at all four corners. The bottoms may be of ½-inch mesh hardware cloth, if seed is to be permitted to sift down from tray to tray, or of screen wire 16 meshes to the inch if, as is often desirable, the seed is to be kept separate by trays. Heavier trays should be built if rough handling is anticipated.

A loft under a hot roof makes an excellent place for air extraction. One of the best air-temperature plants on record was an abandoned work car on a siding, with cone trays where the bunks had been. The effectiveness of the plant depends on good cross-ventilation of cones in single layers, on efficient use of space, and on means of handling the cones a trayful at a time, or with scoops or chutes. The cones and seed must of course be protected from moisture and from mice.

Effective extraction by artificial heat requires that relatively dry air, at a temperature considerably above that of the air outside but still not hot enough to injure the seed, be circulated freely and rapidly among the cones. The highest safe temperature depends upon a number of things, including the species of cone, and has not been determined exactly, but experiments and experience have shown clearly that no harm results with a maximum of 120° F., provided good circulation is maintained, and provided the moisture content of the cones is not too high at the time they are put in the kiln.

The simplest and least expensive type of kiln for the use of artificial heat in extracting pine seed is of the so-called convection type. This depends for its action on the tendency of hot air to rise. It consists of a cell, or a series of cells, each perhaps 3 by 4 feet by 8 feet high, containing trays of cones one above another, with a source of heat below each cell and a generous outlet or series of outlets at the top. Such cells are most conveniently located in a building set well above the ground on posts, or in the upper part of a 2-story building. One such kiln has been constructed inside a sweetpotato house; a much larger one has been installed in the second floor of an abandoned fire-engine house in a small town. The higher the cell, itself, or the higher the combination of cell and the ventilator pipe or flue in its roof, the better will be the upward circulation of air, just as the draft is better in a tall chimney than in a short one. Neither the trays nor the layers of cones in the trays should offer any unnecessary obstruction to the upward air currents; in a kiln of this type it is particularly important to place only a single layer of cones in each tray. Efficiency is lost if there are any clear spaces between the kiln walls and the sides or ends of the trays through which air can ascend freely without passing among cones.

The temperature in such a kiln may be read from a thermometer just above the lowest tray, preferably mounted on an arm to swing it near the center of the kiln. This is usually the hottest part. The thermometer can be read by swinging the arm quickly to a small window built into the back of the kiln. The temperature is controlled by regulating the fire, and to a certain extent by reducing or increasing the air outlet at the top.

Coal is better fuel than wood for an extracting plant. Cones are poor fuel; they make a hot, quick fire that soon dies down, and produce uneven temperatures within the kiln.

The fire hazard in cone kilns is extremely high, because of the high temperature, the ventilation, the finely divided, pitchy fuel all about, and the dust. Extraordinary precautions against accidental fire must be taken at all times. Any furnace or hot-air device in the kiln house itself is a very grave risk. If the extractory represents any considerable investment, it is highly desirable to increase the investment enough to install a steam-heating plant, with the furnace in a separate, fireproof room or building, and to furnish heat through steam coils underneath the cells.

Seed can be extracted in lumber dry kilns if suitable methods of handling the cones can be arranged. What promise to be the most efficient kilns of all are designed like the best lumber dry kilns, with internal-fan-forced circulation, but with dimensions and fittings made especially for cones. Such kilns are expensive (they may cost several thousand dollars apiece), and suitable only for large-scale extaction. For the latest information concerning them, consult the Forest Products Laboratory, Madison, Wis.

After the cones have been opened as completely as possible in the racks at air temperature, or in the kiln, it is necessary to shake out the seed by means of some sort of tumbler. This may consist of a long box or cylinder, covered with ½-inch wire and mounted on a horinzontal shaft. The open cones are dumped in through a door in one side, the door closed, the tumbler revolved about ten times, and the cones emptied out through the door. Such a device is known as an intermittent tumbler. (See figure 2.) A form preferred for large plants is continuous in action, and is similar in covering and mounting, but is larger at one end than at the other, open at both ends, and usually somewhat longer than the intermittent type. In the continuous tumbler the cones are fed into the small end through a chute, or by shoveling, and, as the tumbler revolves, they work down by gravity to the large end and out to a conveyor or other means of disposal.

Either type of tumbler may be revolved by hand or by a motor. The seed falls through the wire sides and is caught in trays placed below the tumbler, or in a large, shallow box on the floor, covered with a grid through which the seed can fall and be protected from trampling until the entire lot has been freed from the cones.

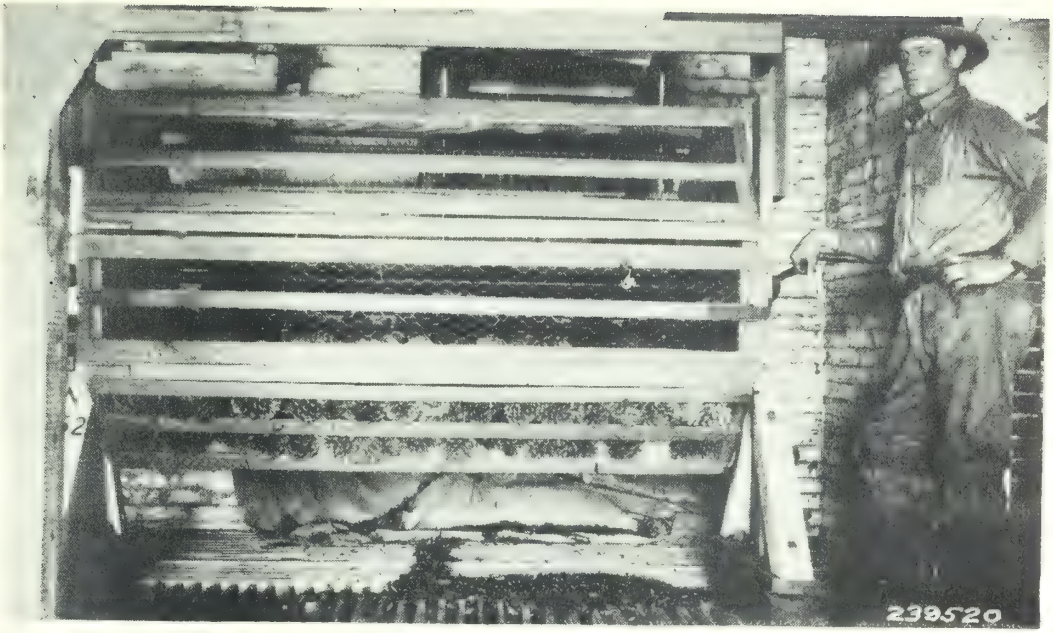

FIGURE 2. -- Revolving, 8-sided tumbler of the intermittent type. Cones are emptied into the tumbler through a chute from the floor above, and are emptied out on a taupaulin laid temporarily on the grid-work cover of the seed box below.

CLEANING SEED

Longleaf seed is usually sown with the wings on, because this species differs from most pines in having wings that are extremely difficult to remove. The seeds of slash, loblolly, and shortleaf pine can be sown much more easily if freed of their wings. This can be accomplished very simply by moistening the mass of seed throughly and spreading in a thin layer on a screen-wire tray in the sun or before a fan to dry. Vigorous stirring with a small rake or a wooden hoe speeds up the drying process and insures loosening the wings of almost all the individual seeds.No injury results provided the seeds are thoroughly dried within 6 or 8 hours after wetting.

Stirring and drying seed as described above works most of the wings to the top of the tray and most of the seed to the bottom. Much of the mass of wings can be removed by hand. More can then be removed by raising the tray shoulder-high, lowering it quickly to the level of the thighs, and swinging it sidewise from beneath the cloud of wings left suspended in the air for an instant before fluttering slowly to the ground. Very fair final cleaning can be accomplished by screening out bits of cone scale larger than the seeds, and by winnowing the screened seed in a brisk wind or before an electric fan. Far better results can be obtained, however, by using an agricultural seed mill with oscillating screens and a vertical air blast. Such mills, in various sizes and with a variety of screens, cost between $30 and $40, greatly improve cleanness of longleaf seed with the wings on, and remove practically all impurities and all but a small percentage of the empty hulls from the seed of slash, loblolly, and shortleaf pines. They are well worth the price to anyone making a regular business of seed collection and extraction.

TESTING AND STORING SEED

A discussion of laboratory tests of the actual germination of fresh and stored seed is beyond the scope of this paper. The extractor and dealer should, however, have a clear idea of the quality of his seed at different stages in the cleaning process, and especially at the time of sale. Fresh seed can be tested for soundness by smashing samples with a hammer, one seed at a time, and recording the percentages sound and empty. If there is doubt about the soundness of seed containing kernels, a more accurate determination can be made by cutting the seeds with a sharp knife and separating the sweet, sound seeds from the softened and discolored ones. Separate samples should be drawn at random from different parts of the lot to be tested; 5 samples of 100 seeds each, if their quality checks within a few percent, give a tolerably accurate measure of the entire lot. Such "hammer tests" and "cutting tests," however, invariably show a higher percentage of sound seeds than do actual germination tests, and should be used with caution in advertising.

In general, seed keeps best in airtight or nearly airtight containers, at low moisture content, and at low temperatures. For storage from the time of extraction in the fall to the time of sowing the following spring, ash cans or garbage cans with tight covers have proved very satisfactory, if kept in unheated buildings. Kiln-extracted seed has shown a tendency to keep somewhat better than seed extracted at air temperature, possibly because of its lower moisture content. Before putting it in cans, it is advisable to expose air-extracted seed to the sun for 6 or 8 hours in shallow layers stirred at frequent intervals, to insure its being thoroughly dry.

Seed to be kept a year or more should be dried thoroughly, stored in airtight or friction-top containers, and kept at a temperature of 35° to 38° F.

All lots of seed shipped or stored should be marked distinctly. The label should show species, date and place of collection, collector, method of extraction, and preferably character of parent trees and data concerning cleaning and degree of soundness.

A13.27

OCCASIONAL PAPER No. 52 October 15, 1935.

SOUTHERN FOREST EXPERIMENT STATION

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WHAT, WHERE, WHEN, AND WHY ARE TERMITES?

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In Cooperation With

SOUTHERN FOREST EXPERIMENT STATION

WHAT, WHERE, WHEN, AND WHY ARE TERMITES?[1]

By

THOS. E. SNYDER, *Senior Entomologist.*

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WHAT AND WHY ARE TERMITES?

The title of this informal address is purposely very presumptuous, since I hope to show that there are many gaps in our knowledge of termites.

It is believed that most residents of New Orleans know what termites are. Nevertheless, in an examination given this year for real estate brokers, one answer to the question, "What is a termite?" was, "An instrument which is set in the wall to indicate how hot or cold the room is." Termites are not thermometers.

Termites represent one of the important groups of social insects, other social groups being ants, bees, and wasps. While superficially resembling true ants, termites belong to an entirely distinct order of insects and are closely related to the Blattidae, or roaches. Indeed, they might be called social roaches. The primitive wingless roaches are wood-boring insects and they care for their young in colonies, as did both ancestral roaches and termites. The wings of primitive termites and modern roaches are similar. The females of both groups extrude eggs in adhering masses or cases. Both insects have free living symbiotic intestinal protozoa. Although they had a common ancestor, roaches are much older, geologically, than termites.

Although termites are called "white ants," and are somewhat antlike in form, they are not related to the more numerous and geologically much more recent ants. Ants have a slim thorax or "waist", while termites have a broad thorax. The fore wings of ants are markedly larger than their hind wings, whereas the termites' wings are of nearly the same size. Both ants and termites live in large nests or colonies, made up of different forms or castes. In these nests or colonies both wingless and winged mature individuals are produced. Unlike the other forms, the brownish or blackish, elongate, slender, antlike, colonizing, sexual adult termites with long whitish wings have functional eyes, and their bodies are able to endure full sunlight. These migratory males and females appear normally once a year during a short period.

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[1] Paper presented before the New Orleans Academy of Sciences, Gibson Hall, Tulane University, November 22, 1934.

Among both the ants and the termites there is a well developed caste system of fertile and sterile forms; or a polymorphism, with a division of labor. Fossils show that the caste system appeared early in the development of termites, and they thus became social insects, whereas roaches did not.

WHERE ARE TERMITES?

Termites occur in all zoogeographical regions of the world, except the Arctic and Antarctic. The Ethiopian region is the richest in species, and the Neotropical, Oriental, and Australian regions also have many species. The Palearctic and Nearctic regions have few termites. Thus termites are not confined to the tropics, but occur in temperate regions throughout the world. Latitude 50 degrees and the mean annual isotherm 50 degrees F. outline the distribution of termites in the world.

There are 1,997 different known species of termites in the world, including 65 fossil species. In the United States there are 56 living species of termites and 9 fossil, and living termites have been found in all states except North Dakota. In Arizona 25 species occur, 20 in Texas, 19 in California, 15 in Florida, and 8 in Nevada; other states have from 1 to 5 species. Only 5 have been recorded from New Mexico, doubtless because of lack of thorough investigation.

Throughout the United States, especially in the Southern, Central, Southwestern, and Pacific Coast States, native termites, or white ants, cause serious damage to the foundations and woodwork of buildings, to articles in the buildings, and to living trees, crops, and other vegetation.

WHEN ARE TERMITES?

Our knowledge of the earlier types of termites, as represented by fossils, is incomplete, but termites are not recent. A fossil wing in Miocene rock of Washington indicates a 55-million-year residence in North America. Termites antedated man; roaches antedated both termites and man. Both probably will survive man, because of better adaptability. Fossils occur in the Eocene and Miocene formations of the world in rock, Baltic amber, and gum copal. Also, fossil termite pellets have been found in Florida, in the more recent in Pleistocene formation.

Termite damage in the past has often been mistaken for decay or dry-rot caused by fungi; it is therefore apparent that the amount of damage caused by termites is greater than it was formerly believed to be. There has been no introduction or spread of termites from the tropics to the United States, nor has there been any spread of our native forms from the Southern to the Northern States. The species are different in the various regions. Examinations of the old colonial dwellings in Virginia which have been attacked and reattacked by termites over long periods, lead some authorities to believe that there are "biologic waves" or periodic rises and falls in the activities of termites, or cycles of greater or lesser damage. But termites have always been here.

As colonies, termites may far outlive man. In South Africa, natives of the Transvaal have venerated certain termite mounds for hundreds of years; the mounds have remained unchanged through the centuries. In the United States, termite queens have been kept alive in artificial colonies for 25 years.

ORIGIN OF CASTES

Polymorphism, or the caste system, in which both fertile and sterile forms occur, has challenged the explanations offered by many exponents of the theory of evolution. A natural explanation is that the castes have originated as segregants from a heterozygous parent form. Not only are there both fertile and sterile forms, but several types of each, including large-winged, "short-winged" (or forms with wing pads), and wingless, as well as intermediate reproductive forms. There are several types of sterile soldiers and workers. Termites colonize new sites by flight and may reach a height of 3,000 feet. They also form new colonies by creepiong migrations underground. Primitive wingless roaches colonized by creeping migrations above ground. When the queen of a termite colony dies, monogamy may be replaced by polygamy, with a consequent change in the type of reproductive form. Cross breeding of three types of sexual adults within the species occurs both in nature and in artificial colonies, but the type of progeny resulting from these crosses is as yet undetermined. The worker caste developed from the soldier. The recent inhibition theory is that mature reproductive forms produce a substance which, when eaten by nymphs, inhibits the functioning of reproductive organs in individuals of the same sex. There is a constant exchange of exudates. Tropical queens become 4 inches long; they are immobile and are imprisoned in a cell. Queens of species native to the United States are small, mobile, and have a low rate of egg laying.

ORIGIN OF FLIGHT

Termites possibly developed flight through first soaring as do other flying animals. The oldest and most primitive insects--the Paleodictyoptera--had lateral notal growths on the prothorax. Such pronotal wing buds are not found on any mature recent insects, but occur on the young of living species of primitive termites. These lobes disappear before the adult stage is reached. These and other morphological and biological data appear to indicate that the development of individual termites--their ontogeny--is a recapitulation of the development or phylogeny of the termite group.

DEVELOPMENT OF DEFENSE ORGANS

Among primitive termites the mandibles, or jaws, of soldiers are strong and sawtoothed; they are designed solely for defense, and cannot be used for chewing wood; in consequence soldiers have to be fed by other castes, as do all types of soldiers. In the intermediate termites a frontal head gland appears as well, often with an elongated, grooved labrum. This is a defense organ, from which exudes an acidulous secretion, that can be ejected for a distance of about an inch. This sticky liquid serves to "gum up" their ant enemies when they attack, or come in contact with, the termites. In the highly specialized termites, only traces of the mandibles remain, or they disappear and the gland becomes very well developed. Chemical or gland warfare is much more effective than war with mandibles in repelling the attacks of ants. In some species, instead of the functional biting mandibles of the generalized lower termites, there are elongate asymmetrical mandibles with which the termites audibly flip or snap themselves out of danger; or it may be that these mandibles are merely signalling organs to warn the colony of danger. There is so much about these insects that is still unknown.

NESTS

Termites were architects and engineers long before man appeared on this planet. Their domiciles were developed through about the same stages as man's, or vice versa.

Primitive termites excavated nests in wood or soil, as do all of our species in the United States. The nests of our native termites are diffused and inconspicuous and the insects move about with changing environment. In the tropics, termite nests are concentrated and often strikingly conspicuous. Here mounds and carton nests in trees, often of odd shapes, dot the landscape. By progressive development, ventilated, air-conditioned, rain-shedding nests appear with the specialized higher termites. Ants, their dominant enemy, have forced termites to dig in, or to wall themselves up in fortresses. The increased termite damage in New Orleans is due not to the control of the Argentine ant but to the lowering of the water table by man.

Termite nests house queer, oddly-shaped insect guests, or inquilines, which live in a symbiotic relationship, thereby obtaining greater warmth or coolness as well as protective shelter. Many diverse groups of animal life, as weird in form as the specialized, toothless animal predators, occur in this manner.

FOOD

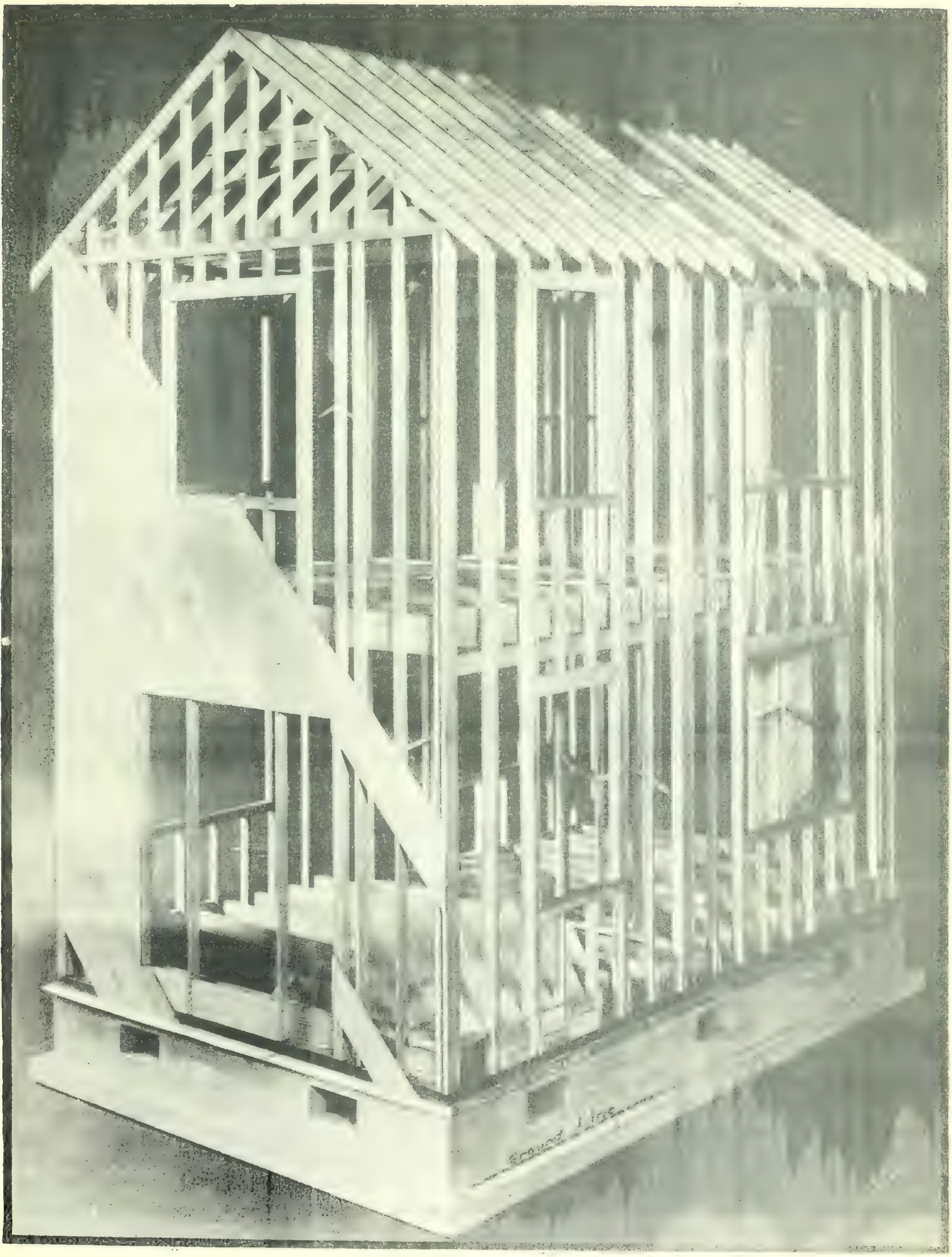
Wood affords termites both food and shelter; its chief constituent, cellulose, is their principal food. Intestinal protozoa in many termites contain enzymes that digest cellulose. The death of these symbiotic protozoa may furnish the necessary nitrogen. With our present knowledge, we can only surmise that these soft-bodied termites, whose bodies are full of juices, must have a wonderful chemical laboratory in their bodies, or certain forms (dry-wood termites) could not live in very dry wood, or without the element nitrogen. It must be that, directly or indirectly through low plant and animal parasites in their intestines, they manufacture water from the air and cellulose, as well as fix atmospheric nitrogen into forms available to them as food--for animals must have nitrogen in order to live. Termites cannot obtain nitrogen from their normal food, which is derived entirely from vegetation.

The role of some of the more primitive and minute organisms found associated with termites is not known. Spirochaetes, intermediate between plants and animals, occur in the intestines of termites, but it is not known what their relation is to the termites. They do not benefit the termites, as do the protozoan Amoebae and Flagellates, which contain enzymes that digest cellulose (the basis of the structure of plants). There is some evidence of a correlation between the evolution, or development through geological time, of these intestinal protozoa and that of the host termites. Not all termites, however, have these helpful protozoa in their intestines.

Subterranean termites carry moisture with them from the soil, often to great heights on trees in their earth-like shelter tubes. Partially dominant, diurnal "wander termites" forage above ground and have color and eyes. Specialized tropical termites grow fungi or mushrooms, or forage for lichens. In the United States, our non-wood-boring termites of the southwestern states feed on cellulose that has been broken down by fungi or other agencies.

TROPISMS

When man studies social insects, he must not be egotistically anthropocentric. We do not know how insects "feel", "taste", "smell", "hear", or "see". We are only sure that these functions are quite different from those in man. In insects, taste and smell may be combined or the reactions may be purely chemical. Insects react to both internal and external stimuli. Such behavior is termed a tropism. At the time of the "swarm" termites behave very queerly. Ordinarily, while in their tunnels, they shun the light or lack of humidity. Yet in the colonizing flight they emerge into the



View of a model termite-proof building suitable for construction in the southern states. Note the metal termite shield and proper ventilation openings. Model especially constructed by the Southern Pine Association in consultation with the Bureau of Entomology and Plant Quarantine.

sunlight, climb to elevations, and fly. After the flight, which is followed by the shedding of their wings, they seek shelter in earth under wood. From animals that choose close quarters in the soil, cling to the earth, and avoid light, they change to animals that seek the light, avoid close quarters in the soil, and seek elevations, and again change these three reactions to the earlier condition--all within a few hours.

DAMAGE

By man's disturbance of the balance of nature in felling and clearing forests and woodlands, his cultivation of the fields, and the encroachment of civilization, evidenced by more extensive building operations, drainage, and irrigation, termites have been forced from their natural habitats and have been driven to attack the woodwork of buildings for both food and shelter. Man has changed the status of termites from the role of scavengers to that of pests. A loss of 40 million dollars annually is a rough estimate of termite damage in the United States; there are no accurate figures.

Ninety-five percent of termite damage in the world is caused by the subterranean type. Practically all damage can be avoided by proper construction. Termites are selective feeders and choose the most suitable species of wood, etc., for food. Much damage by termites to materials such as shoes, lead-sheathed cable, and other substances not containing celluiose is due to the fact that these materials were in the way. Damage to rifles, razor blades, and other impenetrable materials is caused by the corrosive action of moisture brought up by subterranean termites with the earth and excreted wood with which they build tunnels or runways over these metals.

CONTROL

BIOLOGICAL CONTROL.--As termites live protected lives, always concealed either in wood or in the earth, and as their powers of reproduction are enormous, they have very few effective natural enemies. Unlike most insects, they have no internal insect parasites which help to keep them in check. Fungi, nematodes, and molds, however, cause some loss in termite colonies. Of these enemies, molds appear to be the most effective. Among predacious animals, ants are the most important enemies of termites. Ants are active and run about on the surface of the ground. However, termites and ants in nature live side by side and ants do not control termites, mainly because termites are nearly always under cover.

ARTIFICIAL CONTROL BY MAN.--On the basis of studies of the classification and biology of the termites of the world, we can reduce the 1,997 known species to two types: (1) Dry-wood termites and (2) ground-nesting or subterranean termites. In a discussion of control measures, we can disregard all other types.

Insulating untreated wood from the ground by means of concrete or metal barrier shields offers both permanent prevention of, and a remedy for, damage by the ground-nesting forms. The impregnation of construction timbers with chemical wood preservatives is the most effective method of preventing damage by dry-wood termites. Buildings can be termite-proofed at a relatively small cost--from 1 to 2 percent of the initial cost in the case of subterranean termites, and 10 percent of such cost in the case of dry-wood termites. City building codes with brief termite-proofing provisions in the mandatory sections, as recommended by the Bureau of Entomology and Plant Quarantine, are the logical answer to the termite problem.

Recent investigations have shown that where structural changes are impractical, poisoning of the soil about the foundations offers promising results.

CAUTION AGAINST EXAGGERATED FEARS

Without desire to minimize the damage that may be occasioned to buildings and their contents by termite attack, especially if long continued, it should nevertheless be pointed out that serious termite injury to buildings, particularly in the more northern parts of the Temperate Zone, is relatively infrequent; and that termite work may go on for years without involving the necessity for extensive repairs or reconstruction of foundation timbers and flooring. Many instances could be cited of old houses, dating back to colonial times, in which the presence of termites has been known for 50 years, probably for two or three times that period, without radical injury resulting. Such immunity is due, in part, to the more massive timbers used in these older types of houses, the foundation beams of which were often of large size and hewn from the mature centers of hardwood trees.

Once having invaded a building, however, termites will continue their work and extend their damage slowly or rapidly, unless and until their means of entrance from the outside has been removed by effective reconstruction. With the breaking of the connection between the building and the external soil moisture, all the subterranean termites in the building promptly die and injury ceases.

While, therefore, the risk of sudden collapse of any fairly well-constructed building, solely from termite injury, can be dismissed as very rare in the United States, the discovery of termites in a building, as indicated either by swarming or by yielding flooring and timbers, certainly indicates the desirability of having an examination made to determine what means should be taken to stop damage.

CONCLUSION

Each section of this paper has shown that there is a vast lack of knowledge of the biology of these insects, and with this in mind, you can imagine how one feels when a visitor, seeking information, introduces himself by saying, "I have come to you, who know everything about termites". The purpose of this brief address is to stimulate interest in termites. Details on their control can be obtained by writing to the Bureau of Entomology and Plant Quarantine, Washington, D. C., or to the Southern Forest Experiment Station.

1. - The metal termite shield inserted over concrete foundation; foundation wall ventilation openings should be 2 sq. ft. per 25 lineal feet; the wooden fence should be isolated from the woodwork of the building.
2. - Mud sill impregnated with coal tar creosote.
3. - Metal shield over concrete capping on brick foundation pier
4. - Wooden steps separated from woodwork of building by a metal sheet.

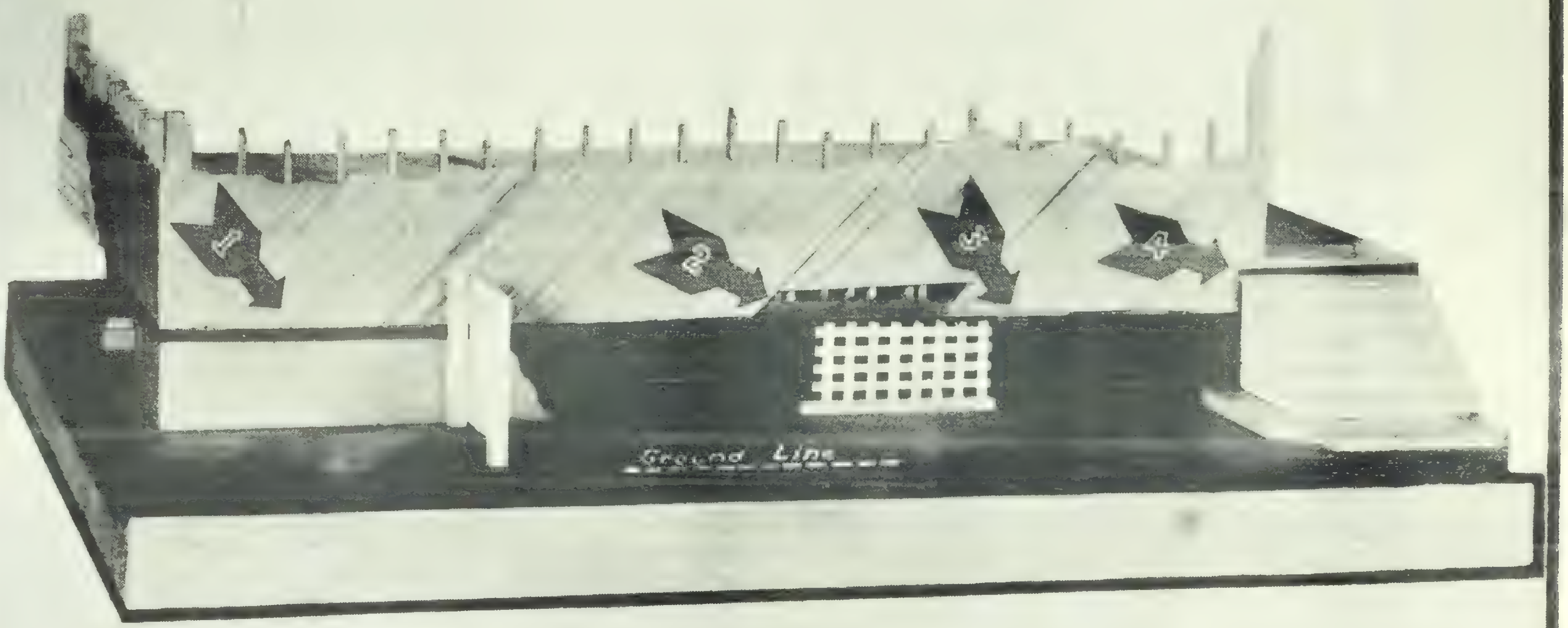


Diagram of the various types of masonry foundations for frame buildings suitably capped at the top and equipped with metal termite shields; the fence and steps isolated from the house and lattice work on concrete base. Model especially constructed by the Southern Pine Association in consultation with the Bureau of Entomology and Plant Quarantine.

OCCASIONAL PAPER No. 53 November 20, 1935.

SOUTHERN FOREST EXPERIMENT STATION
E. L. Demmon, Director
New Orleans, La.

USE OF LAND FOR FORESTS IN THE LOWER PIEDMONT REGION OF GEORGIA

By

W. E. BOND, *Forest Economist.*

and

A. R. SPILLERS, *Associate Forest Economist.*

This paper releases data gathered in current investigations of the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

FOREWORD

The study reported in this paper was made under an agreement signed August 15, 1933 between the Regents of the University System of Georgia and the following branches of the United States Department of Agriculture: The Bureau of Agricultural Economics, the Southern Forest Experiment Station, and the Bureau of Chemistry and Soils. When the Division of Program Planning of the Agricultural Adjustment Administration was organized in 1933, the Land Policy Section of that Division continued the cooperation of the Bureau of Agricultural Economics.

The study was made in the Lower Piedmont Region of Georgia. Its primary purpose, as stated in the Memorandum of Agreement was:

"To determine, for the territory covered, the elements of a land utilization program, based upon a thorough study of physical conditions, present methods of utilization, and economic and social factors which tend to determine present and prospective utilization, and which should be taken into consideration in determining the adjustments requisite in a sound program of land utilization."

This report is the part contributed by the Southern Forest Experiment Station to the project. Portions of this report were published by the Georgia Agricultural Experiment Station as Chapter VI in Bulletin #191, "Georgia Land Use Problems." Because the edition of that bulletin was limited, the present report is being published in full in order to reach all those who are primarily interested in the forests.

E. L. DEMMON
Director

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USE OF LAND FOR FORESTS

IN THE LOWER PIEDMONT REGION OF GEORGIA

By

W. E. BOND, *Forest Economist,*
and
A. R. SPILLERS, *Associate Forest Economist.*

THE REGION

LOCATION AND DESCRIPTION

The Lower Piedmont Region of Georgia includes about 35 counties located in the central part of the State. (See figure 1). This area of about 7,254,400 acres is bounded on the east and west by the state lines of South Carolina and Alabama, and on the south by the Fall Line, a topographic demarcation between the Piedmont or foot-hills and the coastal plain, that extends approximately from Augusta through Macon to Columbus. In the north the Lower Piedmont Region may be separated arbitrarily from the Upper Piedmont Region by a line passing just south of Atlanta that extends from Hartwell to Carrollton. The Lower Piedmont Region extends into Alabama, South Carolina and North Carolina. Much of the information given in this report will apply to the region in those states as well as to Georgia.

On the whole, the Lower Piedmont is a gently rolling area, adequately drained by some streams that flow southward into the Gulf of Mexico and by others that flow southeastward into the Atlantic Ocean. Its soils, represented chiefly by the Cecil and Davidson series, are derived from ancient igneous and metamorphic formations. The average annual rainfall is about 45 or 50 inches, and the mean annual temperature for the region is between 60 and 65 degrees. An average growing season of about 8 months is conducive to the production of both agricultural and forest crops.

The Lower Piedmont Region is often described as the "old plantation section" because for many years individual land holdings have been so large that usually each owner has employed some tenants or croppers to farm his land. This system of farming still prevails today. Cotton, the principal crop and source of income, has been largely instrumental in forming the present social and economic system in this region. The population in 1930, 53 percent of which was white, numbered 495,196, or 43.6 persons per square mile. Most of these people have always been farmers, but within the last decade the textile industry has developed in the area and has encouraged an increase in population in some of the small towns. The term "old abandoned planta-

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The authors wish to acknowledge their indebtedness to all who have aided in any way in the accomplishment of this project, particularly to:

Dr.W.A. Hartman and H.H. Wooten of the Land Policy Section, Division of Program Planning, Agricultural Adjustment Administration, who have planned and carried out the Land Utilization Project as a whole and have furnished the land use areas and tax data for this report; State Forester, B.M. Lufburrow, who assigned an assistant for field work; W.G. Wallace, District Forester, Georgia Forest Service; Professor G.L. Fuller of the University of Georgia; Mr. Hasty of the Bureau of Chemistry and Soils; A.D. Read, representing the Southern Forest Experiment Station; and W.P. David, representing the Bureau of Agricultural Economics and the Southern Forest Experiment Station.

tion section" would more accurately describe this region, for abandoned fields are ubiquitous. Old abandoned fields are now reforested to such an extent that 55.6 percent of the total area may be classed as forest area; yet more than two-thirds of the timberland has been cultivated at one time or another.

HISTORY OF THE REGION

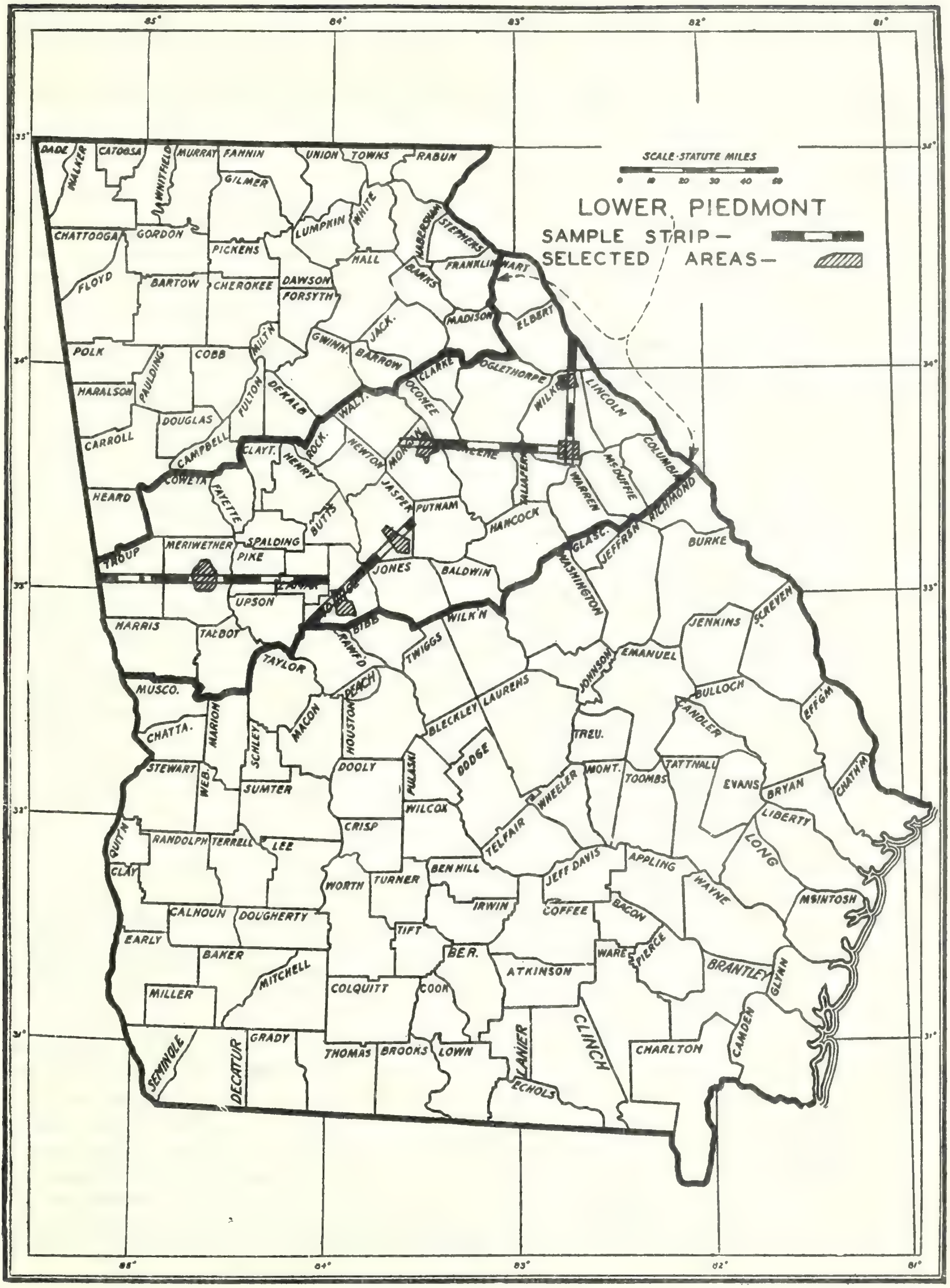
The Lower Piedmont Region of Georgia was settled during the last quarter of the eighteenth and the first quarter of the nineteenth centuries by immigrants from the older settlements of Georgia, Virginia, and the Carolinas. Prior to 1800 the region west of the Oconee River was Indian territory and settlement was limited to areas east of that river. Early in the 19th century the settlers made treaties with the Indians and the land was opened to those from Georgia by lottery, but it was also sold to immigrants who flocked in from Virginia and the Carolinas. The land was soon afterwards dotted by small farms. The first settlers cleared the rich lands on the rivers and creeks, and raised live stock, corn, and wheat. They also cleared, to some extent, the pine uplands. Cotton and tobacco were of little importance until trade received a great impetus after the war of 1812. At first the farms were held by relatively poor men with very few slaves; but as soon as an excellent market for cotton developed, the wealthy planters began to buy up the best land in large blocks and the small owners moved farther west.

Before the Civil War the Lower Piedmont Region of Georgia had become a cotton empire rivalling the coast states. A decade or two after this conflict, the region, having slowly recovered from its economic setback, again became a large factor in the production of cotton. From that time until about 1920 it remained a relatively prosperous region. Since early times, however, the wealth of the country has been concentrated in the hands of a few people. The land-owning class of pre-war days had profited from the labors of the slaves and poor whites, with the resulting contrast in standards of living exemplified by the palatial planter's home and the slave shacks or "quarters." During the Reconstruction and afterward, this social condition remained unaltered, for the land-owning class built the big homes, usually in the small towns, and rented the land to tenants and sharecroppers.

With little supervision from their town-dwelling landlords, these tenants and sharecroppers have never been careful to adopt conservative measures of cultivation. It matters little to them that the cotton plant exacts much from the soil and gives no protection from erosion during almost half the year; therefore until recently, soil cover crops and terraces were practically unknown. Old residents in the section recall days when furrows were plowed at right angles to the contours "so each furrow could drain itself", or when a mark was placed at one end of the field so that a plowman, in making his first furrow, headed directly toward his mark regardless of the topography. The light sandy soils of this region eroded so easily that many of the fields, within a few years after having been cleared, became unfit for agriculture and had to be abandoned. But land was plentiful and could be had for the cost of clearing the forest; when one field was abandoned, another area was cleared.

The boll weevil began its wholesale destruction of cotton in 1920, and until checked several years later, this pest continued to devastate entire crops. The crop loss in 1922 was so nearly complete that the financial structure of the whole region, which was directly connected with agriculture, was severely damaged. During the subsequent years of agricultural depression leading up to the present, recovery has been slow. Compared to erosion, however, which has rendered the land physically unfit for farming, the boll weevil has been but a minor factor in weakening the economic structure of the region.

FIGURE - 1



LOCATION SAMPLE STRIPS AND SELECTED AREAS IN LOWER PIEDMONT GEORGIA

When the land was first cleared for agriculture, trees were cut and burned. Old residents recall the "log rollings" of early days: social events in which farmers would gather at a given plantation and help to clear the land. Months prior to the "log-rolling" the timber had been girdled so that it would be dry. Fine, big, old shortleaf and loblolly pines, oaks, yellow poplars, and other hardwoods were cut, rolled together, and burned. Much of the forest area was thus cleared and only a minute fraction of the vast quantities of original growth timber was utilized for local construction.

More than four-fifths of the Lower Piedmont Region has been cleared at one time or another, but much of this cleared land has been abandoned. The great scarcity of labor following the Civil War resulted in the abandonment of much crop land; and again between 1919 and 1932, owing to the combined agency of erosion and post-war decline in the cotton market, crop acreage decreased about 42 percent.

A large percentage of this abandoned crop land has seeded-in to pine, so that today the old field pine timber makes up a large part of the total forest area, as well as a large part of the total area of the Region. With very few exceptions this region has never known large sawmills. Small sawmills came here about 1913 from the Carolinas and began to cut boards. They obtained their stumpage partly from the small remnant of old-growth timber, but mainly from the old field stands. Following the severe losses from the boll weevil invasion, the farmers found relief in the sale of timber.

At first the small sawmill operators paid very little for stumpage, but the world war boom encouraged high prices for lumber and resulted in increased stumpage prices. The small sawmill industry developed rapidly after the War; the peak of lumber production in this region was reached in about 1924. By 1929 lumber manufacturing had already shrunk far below that of the peak year, and today it is at a low ebb. This condition is due not only to the present depression of the lumber market, but also to the rapid diminution of the timber supply. The forest often saved the cotton planter from bankruptcy; but when he sold his timber he considered only his immediate gain--and as a result the forest has been left in a poor condition.

PRESENT LAND USE

According to the 1930 census, only 22.5 percent of the total land area in the Lower Piedmont Region of Georgia is "harvested" crop land; but about 43 percent of the Region is classed as agricultural, which includes crop, pasture, and idle land. Forested land occupies 55.6 percent of the area and urban districts make up the remainder.[1]

Large plantations with sharecroppers and tenants are still characteristic of this region, where about half of the crop land produces cotton. Cover and soil improvement crops are used on some of these plantations, and contour plowing and terracing are slowly increasing in popularity; but much of the land is still being farmed in such a destructive manner that serious erosion is everywhere apparent. Here, where 40 percent of the cleared land is idle, erosion is the chief agent in the widespread abandonment of land. The fourfold cycle of (1) woodland clearing, (2) farming without erosion control, (3) abandonment, and (4) subsequent reforestation, is as common today as in earlier eras; but most of the clearing done now is in woodland that was once field, hence the rate of abandonment is greater than that of clearing.

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[1] See table 1 in the Appendix for details by counties.

Fortunately, however, abandoned land does not remain idle very long in most parts of this region. If a cultivated field adjacent to pine seed trees is abandoned, a young forest will soon reclaim the land. Given ordinary protection from fire, especially in the early stages of their growth, these young stands usually develop into forests. Over two-thirds of the present forests, occupying about 37 percent of the total area of the Lower Piedmont, are of old field origin; whereas natural forest land that has never been cleared occupies only about 18 percent of the area.

FOREST CONDITIONS

TYPES

Two methods of field procedure were followed in studying forest conditions of the Lower Piedmont Region. The first plan involved an intensive investigation in six sample areas, each about 16 square miles in extent, which were chosen as representative of the predominating soils. The forest on the sample areas was mapped according to type, size of trees, density, and merchantability; at the same time the soil, slope, erosion, and other characteristics of the land were also mapped. Forest classifications comparable to those mapped were sampled by taking one-fourth acre plots every one-sixteenth mile on parallel lines spaced one-half mile apart. Two sample areas were located in Wilkes County and one in each of the following: Jasper, Meriwether, Morgan, and Monroe Counties. The second field method involved the mapping of the forest types, tree sizes, density, and other data on a strip running across Georgia through the Lower Piedmont Region. This strip was one-eighth of a mile wide and 208 miles long; it was run generally in a westward direction. (See figure 1).

These field studies have shown that the old field pine type occupies about two-thirds of the forested area in the Lower Piedmont Region of Georgia. Wherever shortleaf and loblolly pine seed trees grow near an open area, they quickly restock it after abandonment. Loblolly pine is usually slightly more abundant than shortleaf. Hardwoods too, such as red gum, dogwood, elm, maple, and oak, are sometimes found in the old field type, but they are subordinate components of the stands. In cutover stands, however, hardwoods become more numerous. The old field type occurs most commonly on slopes of average steepness that lie between the tops of ridges and the more precipitous slopes to streams. Such situations were once cleared but due to sheet and gully erosion, they have since been abandoned.

The upland pine type, which includes only upland forested tracts that have never been cultivated, occupies about 10 percent of the total forest area. Included in this type are stands containing shortleaf and loblolly pines and hardwoods. Shortleaf usually predominates over loblolly in the stands, but the hardwoods may predominate over both. Hardwoods in the upland pine type include oak and hickory, with red gum, yellow poplar, dogwood, and other hardwoods sometimes in evidence. Most of the stands in this type are confined to the dry ridges and steep slopes.

The pine hardwood type represents about 11 percent of the forested area of the region. This type includes those characteristically fast-growing stands of mixed pine and hardwoods found upon second-bottom and branch-head sites. Loblolly pine is more commonly found here than shortleaf. The hardwoods usually associated with the pines in this type are yellow poplar, red gum, oak, hickory, maple, sassafras, ash, redbud, and elm. Rarely is this type found upon land that has been cultivated, since cultivation of the precipitous slopes of the branch-head sites and of the poorly drained second-bottoms was not usually attempted.

About 11 percent of the forest land falls in the bottomland hardwood type whose stands are composed almost entirely of hardwood trees. This type, as its name implies, is confined to the bottomland of the rivers and larger creeks. A wide variation in hardwood species is found, including water oaks, gum, ash, willow, elm, maple, and hackberry. In some places this type is found on land that has been cultivated, but generally the sites are too poorly drained for agriculture.

Where the stands have not been cut and are growing upon old fields, the trees are generally even-aged, although they offer a considerable variation in diameter classes. Logged old field stands tend to become uneven-aged, for the general practice is to disregard the trees that are too small or too poor for sawlogs. Forests growing on land that has never been cultivated are uneven-aged and generally have a wide range of diameters.

MERCHANTABILITY

After two decades of cutting by small sawmills, which are especially efficient in gleaning small patches of timber, only a small part of the forested area in the Lower Piedmont Region of Georgia still bears good stands of sawtimber. The one-quarter acre sample plots were classed as sawtimber if they contained a minimum volume per acre of 1,000 board feet (International one-quarter inch kerf rule) in pine trees that measured nine inches or over in diameter at breast height. Sawtimber stands of this volume are merchantable in the Region. This does not mean, however, that all plots so designated can be profitably harvested, since most of the sawtimber stands are small in area and widely scattered. About half the plots in each forest type that included pine contained 1,000 board feet or more. Table 1 shows the distribution of sawtimber plots by types for each of the six sample areas. Much of the sawtimber that has a sale value at present is in small scattered patches where logging is difficult and comparatively expensive even with small sawmills. No attempt is made to give an estimate of the total volume of timber in this region, since the available data are not sufficient to make an accurate estimate.

DENSITY

For old field pine stands, which represent the major part of the forested area, an additional classification was made on the basis of the density of stocking. Stands were classified into three density classes: Well stocked (at least 50 percent of full stocking), medium stocked (25 to 50 percent of full stocking), and poorly stocked (less than 25 percent of full stocking). Table 1 shows the distribution of one-quarter acre plots by the three degrees of density for old field stands in the six sample areas. The plots were almost equally divided among the three density classes. Large-sized areas of well-stocked stands are not common in the Lower Piedmont Region where the forests, generally, are understocked.

The outstanding reasons why the forests in this region are poorly stocked are the inadequate number of seed trees and the prevalence of fire. Many of the abandoned fields are too remote from forested areas with seed trees. But even in the natural forest area stocking is generally low because most of the trees of seed-producing size have been logged. Much of the reproduction is killed by fire. According to the one-quarter acre plot samples, about 14.8 percent of the forest area burned over in 1932. Fires are usually due to the negligence of brush-burners, hunters, or campers, although an occasional incendiary may deliberately fire the woods.

Erosion, too, plays its part in preventing adequate stocking. Wherever abandoned lands have eroded so badly that their fertile top soil has been washed away and gullies have been formed, even the pines may find it difficult to establish naturally a forest of adequate stocking. The moist, sandy gully bottoms are ideal seed-beds for pine, but erosion there may be so active that the pine cannot become established. Steep gully banks are difficult sites for reforestation; but wherever erosion is not too rapid and pine seed trees are located nearby, the eroded areas may be naturally reforested. New stands of this type, however, may be somewhat uneven-aged, for the better sites will be seeded first, whereas the poorer sites may not be reforested until the first trees of the new stand, together with other vegetation, have further checked the erosion.

ADDITIONAL AREAS AVAILABLE FOR FORESTS

Other areas, in addition to the land classed as actual forest, will be available for forest growth if the better lands alone are to be used for agricultural purposes. These will include the land now lying idle and generally abandoned because of serious erosion, steep slope, or infertile soil. Forty percent of the open land in both the sample areas and the strip across the state was found to be idle, and about 70 percent of this idle land was classified as unfit for either agriculture or pasture--that is, it was suitable only for forests. Since 43 percent of the Lower Piedmont Region is cleared land, and 40 percent of the cleared land is idle, about 17 percent of the entire region is idle. If 70 percent of the idle land is suitable only for forests, then about 12 percent of the total area of the region is idle land that should be added to the present forest area (55.6 percent of the regional area) to make a total of about 68 percent of the Lower Piedmont Region in present or potential forests. In the above discussion it is assumed that all of the land now being cultivated, as well as the idle land that is suitable for cultivation or pasturage, will continue in that category. The present federal program of removing submarginal land from agriculture, however, may increase still further the 68 percent of forest area in the region.

VOLUMES AND GROWTH

Stand tables, volumes, and annual growth in volume in each of the six sample areas were computed for each class of stand in each forest type. Volume in rough cords was figured for the pine trees in the diameter classes 2, 4, 6, and 8 inches, and the averages of the six sample areas show about 6 cords per acre in well stocked, 2.5 cords in medium stocked, and 1 cord in poorly stocked old field pine stands. Details for all stands are given in table 2. Volumes and volume growth for the large trees were computed differently. Since pine trees over 9 inches (d.b.h.) represent the sizes commonly utilized for lumber, their volumes were computed in board feet with the use of the International one-quarter inch kerf rule because this rule approximates the volume that can be cut out at the mill.

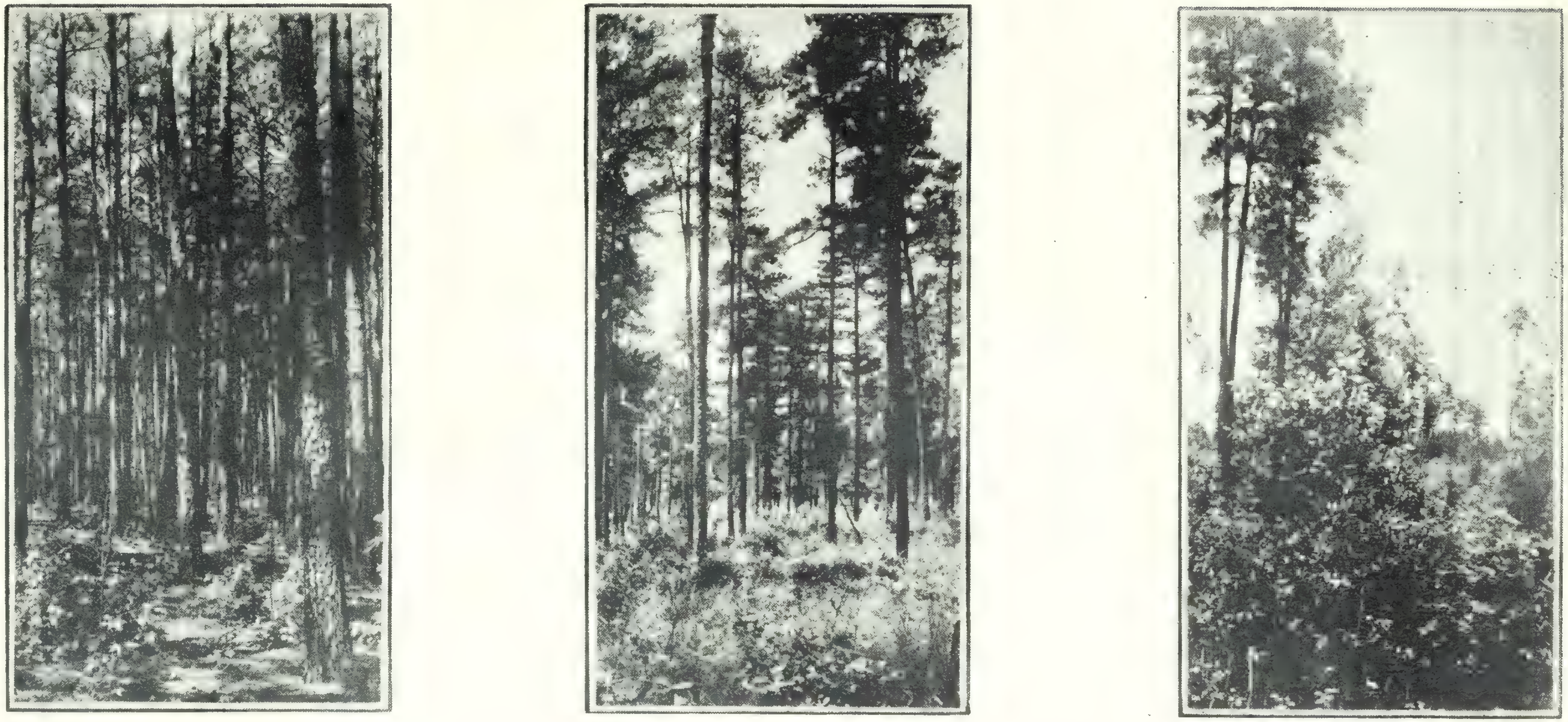
The importance of good stocking of the forest is forcibly brought out by the volumes and increments of three old field pine stands of different densities, which are averages for the six sample areas. These volumes and increments are as follows: Well stocked, 5,179 board feet volume, 493 board feet increment; medium stocked, 3,606 board feet volume, 338 board feet increment; and poorly stocked, 1,989 board feet volume, 164 board feet increment. Details for each stand class are given in table 3.

Table 1. - Plot distribution in forest stand classes by types in the six sample areas

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average Percent
	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	
Old field pine type:													
Sawtimber well-stkd.	27	14.7	18	9.9	19	12.9	28	24.1	45	25.6	17	14.1	16.9
Young well-stkd.	33	17.9	20	11.0	14	9.5	22	19.0	31	17.6	32	26.4	16.9
Sawtimber med. stkd.	33	17.9	36	19.8	39	26.6	21	18.1	38	21.6	31	25.6	21.6
Young med. stkd.	35	19.0	32	17.6	19	12.9	14	12.1	22	12.5	12	9.9	14.0
Sawtimber poorly stkd.	22	12.0	25	13.7	27	18.4	16	13.8	14	7.9	15	12.4	13.0
Young poorly stkd.	34	18.5	51	28.0	29	19.7	15	12.9	26	14.8	14	11.6	17.6
	184	100.0	182	100.0	147	100.0	116	100.0	176	100.0	121	100.0	100.0
Other than old field pine:													
Sawtimber pine & hdwd.	15	53.6	8	17.8	19	55.9	12	42.9	31	75.6	23	79.3	54.2
Young pine & hdwd.	13	46.4	37	82.2	15	44.1	16	57.1	10	24.4	6	20.7	45.8
	28	100.0	45	100.0	34	100.0	28	100.0	41	100.0	29	100.0	100.0
Sawtimber up. pine	10	41.7	10	31.2	22	55.0	8	26.7	11	37.9	24	68.6	43.5
Young up. pine	14	58.3	22	68.8	18	45.0	22	73.3	18	62.1	11	31.4	56.5
	24	100.0	32	100.0	40	100.0	30	100.0	29	100.0	35	100.0	100.0
Bottom-land hdwd.	29	100.0	17	100.0	7	100.0	16	100.0	19	100.0	32	100.0	100.0
Forest-land total	265		276		228		190		265		217		

Total number of plots - 1441

FIGURE 2.



Well-stocked

Medium-stocked

Poorly-stocked

Old Field Pine Stand

Numerous mill scale studies have shown that pine trees below 13 inches (d.b.h.) are commonly cut at a financial sacrifice; hence in considering sawtimber volumes and increment for the region, this report includes only the trees over 13 inches. Volumes and increments by classes of stands were therefore computed on this basis; for the old field stands cited above they are as follows: Well stocked, 2,670 board feet volume, 265 board feet increment; medium stocked, 1,763 board feet volume, 261 board feet increment; poorly stocked, 964 board feet volume, 143 board feet increment. Details of all stands are shown in table 4.

Hardwoods are not a factor in old field stands. In the pine hardwood stands along branches in the six sample areas, the average volumes of hardwoods and pines in trees over 13 inches (d.b.h.) are 1,717 and 2,364 board feet respectively; the increments, 86 and 94 respectively. Detailed volumes and volume growth for hardwoods are given in table 5. In order to show the distribution of both pines and hardwoods by diameter classes, stand tables for the various stand classes in the Jasper sample area, taken as an example of the six sample areas, are given in tables 6 and 7. These tables show that most of the trees are below sawtimber size.

TABLE 2. -- *Volumes per acre in cords for pine trees under 9 inches, (d.b.h.)*

Class of stand	Jasper	Monroe	Wilkes A.	Wilkes P.	Meriwether	Morgan	Average volume
Old field pine:							
Sawtimber well-stkd.	4.25	5.93	5.04	7.23	5.80	6.06	5.72
Young well-stkd.	4.75	6.80	3.08	7.69	6.33	5.82	5.74
Sawtimber med.stkd.	2.25	2.46	2.68	2.56	2.15	2.60	2.46
Young med.stkd.	2.11	3.23	2.89	2.40	2.43	2.81	2.64
Sawtimber poorly stkd.	.68	.90	1.28	.95	.40	.98	.86
Young poorly stkd.	1.42	1.15	1.40	.44	1.48	.89	1.13
Other than old field pine:							
Sawtimber pine & hdwd.	1.21	0.00	.67	1.48	1.24	.87	.91
Young pine & hdwd.	1.31	.50	.20	.78	.96	.49	.71
Sawtimber up.pine	1.53	2.20	1.71	2.31	4.56	1.74	2.34
Young up.pine	.14	.44	1.14	1.42	2.18	1.08	1.07

Table 3. - Pine volumes and growth per acre for pine trees over 9", diameter breast height

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average	
	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth
	------------------ Board feet[1] ------------------													
Old field pine type:														
Sawtimber well-stkd.	4735	421	4651	397	7178	377	6102	591	5391	505	3016	668	5179	493
Young well-stkd.	94	239	197	163	113	9	229	207	259	316	94	191	164	188
Sawtimber med. stkd.	3797	339	3302	295	3378	341	3959	449	3226	302	3974	305	3606	338
Young med. stkd.	116	134	154	160	227	206	110	72	187	181	0	103	132	143
Sawtimber poorly stkd.	2030	185	1882	156	1952	219	2031	94	2252	112	1788	219	1989	164
Young poorly stkd.	117	183	209	108	241	112	230	39	186	121	182	50	194	102
Other than old field pine types:														
Sawtimber pine & hdwd.	2546	127	2784	43	2735	45	3832	95	3053	141	2301	123	2875	96
Young pine & hdwd.	631	63	208	24	278	7	333	72	476	49	306	43	372	43
Sawtimber up. pine	3209	64	3029	128	3860	178	3188	140	4095	397	3514	185	3482	182
Young up. pine	85	3	163	23	291	63	251	37	143	45	346	72	213	40

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[1] International 1/4" kerf rule.

Note: Annual growth takes into consideration the increase in volume of sawtimber trees, the increase due to trees growing into the minimum sawtimber diameter class and the trees lost annually due to mortality.

Table 4. - Volumes and growth per acre for pine trees over 13", diameter breast height

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average	
	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth
	Board feet [1/]													
Old field pine type:														
Sawtimber well-stkd.	2852	203	2189	218	3987	254	2529	432	3339	237	1123	245	2670	265
Young well-stkd.	16	5	34	4		4		22	35	15	33	8	20	10
Sawtimber med. stkd.	2186	243	1724	252	1623	226	1591	377	1780	185	1676	281	1763	261
Young med. stkd.	30	6		15	57	5	69	9		17			26	9
Sawtimber poorly stkd.	939	198	901	158	759	153	1175	59	1435	97	574	191	964	143
Young poorly stkd.	16	7	28	17	43	19	37	25	41	10	114	13	46	15
Other than old field pine type:														
Sawtimber pine & hdwd.	1805	122	2497	69	2287	77	3450	96	2274	139	1872	61	2364	94
Young pine & hdwd.	454	38	92	12	200	13	129	30	284	29	176	14	222	23
Sawtimber up. pine	2584	83	2185	94	2474	165	1625	188	3167	120	2303	181	2390	138
Young up. pine		14	71	13		26	99	13	35	4	114	16	53	14

[1/] International 1/4" kerf rule.

Note: Annual growth takes into consideration the increase in volume of sawtimber trees, the increase due to trees growing into the minimum sawtimber diameter class and the trees lost annually due to mortality.

Table 5. - Volumes and growth per acre for hardwood trees over 13", diameter breast height

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average	
	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth
	----------	----------	----------	----------	----------	----------	Board feet	----------	----------	----------	----------	----------	----------	----------
Sawtimber pine & hdwd.	1917	96	1577	79	2200	110	1455	73	2106	105	1045	52	1717	86
Young pine & hdwd.	1396	70	3692	185	1997	100	2461	123	2901	145	5019	251	2911	146
Sawtimber up. pine	2343	117	868	43	1103	55	910	46	778	39	326	16	1055	53
Young up. pine	3194	160	1736	87	1308	65	848	42	1199	60	300	15	1431	72
Bottom-land hdwd	3236	162	2017	101	2544	127	756	38	996	50	1536	77	1848	92

Note: Annual growth takes into consideration the increase in volume of sawtimber trees, the increase due to trees growing into the minimum sawtimber diameter class and the trees lost annually due to mortality.

Table 6. - Stand table for the old field pine type in the Jasper county area

Diameter breast height	Sawtimber well stocked		Young well stocked		Sawtimber medium stocked		Young medium stocked		Sawtimber poorly stocked		Young poorly stocked	
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	------------	------------	------------	Number	of trees	per acre	------------	------------	------------	------------	------------	------------
2	202.22	37.04	348.48	9.09	53.33	36.36	151.43	34.86	27.27	36.36	50.59	30.00
4	77.78	15.56	184.85	4.85	29.69	24.85	75.43	8.57	5.46	9.09	27.06	9.41
6	55.56	1.48	106.66	2.42	27.88	8.48	41.71	7.43	10.00	7.27	20.58	3.53
8	28.89		19.39		18.18	.61	10.86	1.71	6.37	7.27	14.71	
10	17.03	.44	1.09	.36	11.52	.48	1.26	.11	8.18	1.45	1.53	.47
12	10.96	.44	.24	.24	11.15	.48	.23	.23	7.27	.55	.24	.59
14	6.07	.59	.12	.24	4.49	.97	.22		2.91	.36	.12	.24
16	3.26			.12	3.51	.36			1.09	.36		.35
18	2.66	.15			1.94	.73			.91	.36		.12
20	2.22				1.45	.24			.18			
22 & up	1.04				.48				.36			
Total	407.69	55.70	660.83	17.32	163.62	73.56	281.14	52.91	70.00	63.07	114.83	44.71

TABLE 7. -- *Stand table for the Jasper County area*

Diameter breast height	Pine and hardwood type				Upland pine type				Bottomland hdwd. type
	Sawtimber		Young		Sawtimber		Young		All classes hardwood
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	
	Number of trees per acre								
2	24.00	118.67	16.92	109.23	32.00	76.00	11.43	62.86	132.42
4	17.33	57.34	15.39	53.84	14.00	32.00	12.86	37.15	83.45
6	21.33	33.33	18.46	36.93	22.00	26.00		31.49	50.36
8	5.33	17.34	6.16	24.62	6.00	10.00			21.38
10	5.87	6.40	1.23	4.62	2.00	4.00		5.15	5.94
12	4.80	3.20	1.23	7.99	5.20	5.60	.86	4.01	5.38
14	4.54	4.00	1.54	3.39	2.00	2.40		2.01	2.49
16	2.67	3.21	.62	2.78	1.20	2.40		1.44	3.45
18	1.33	2.40	.62	1.24	1.20	2.40		2.30	2.63
20	1.06	1.06		.93	2.00	1.20		2.00	1.68
22 & up	.53	.27		.62	1.60	3.20		4.87	2.10
Total	88.79	247.22	62.17	246.19	89.20	165.20	25.15	153.28	311.28

A few of the 1,441 sample plots taken on the strip survey show excellent volume and yield, although nothing has been done consciously to assist this growth. Twenty of these natural stands of optimum condition and productivity may give some idea of the maximum yields that can be expected. Possibly these stands, which were found on only a minute portion of the area, were growing upon only the very best sites; but since they are natural stands, it may well be possible to grow forests somewhat comparable to them if careful forest management is practiced upon average sites. The best one-quarter acre plot had a volume of 47,704 board feet per acre at 77 years from seed, and the average of the 20 optimum plots had 20,382 board feet per acre in trees over 13 inches (d.b.h.) at 65 years. Unless the general poor quality of the material is considered, however, all sawtimber volume and growth figures for this region may be misleading. Excessively limby trees and other trees of poor quality are included in these figures because they are utilized in this region for boards, the principal product. Only a very small percent of the stumpage will produce better than Number 2 common boards of the Southern Pine Association specifications.

All increments take into consideration the increase in volume of sawtimber trees, the increase due to trees growing into the minimum sawtimber diameter class, and the trees lost annually through mortality. The annual mortality of pine in each forest type by diameter classes, as found from a tally of dead trees on the one-quarter acre plots, is given in table 8. It is generally one or two percent of the total number of trees per acre. The rate of diameter growth of pine in all stand classes is quite rapid, but is especially so for old field pines up to about the 14 inch diameter class, where, probably because of density, it falls off rapidly. The rate of diameter increase is also less in the better stocked stands. A 10 inch old field pine, for example, increases in diameter during a 5 year period as follows: In well stocked stands, 2.05 inches; in medium stocked, 2.20 inches; and in poorly stocked, 2.50 inches. Diameter growth by diameter classes and by classes of stands is given in table 9.

The effect of erosion upon the growth of forests is difficult to measure. When forests reclaim eroded land, a long period of time elapses before the impoverished soil is enriched with organic material. This period is affected greatly by fire. The forest growth is further retarded until the soil is built up to a condition of fertility and good composition. Density and the many factors of site, however, are so influential in the rate of growth that it is difficult to establish the effect of erosion alone upon forest growth.

TABLE 8. -- *Annual mortality of pine in the six sample areas*

Diameter breast height	Old field pine type	Pine hard-wood type	Upland pine type
Inches	*Percent of number of trees per acre*		
2	1.2	0.5	0.6
4	1.5	1.4	1.8
6	1.8	2.2	2.2
8	1.8	2.5	2.2
10	1.7	2.4	2.2
12	1.6	2.4	2.2
14	1.4	2.3	2.2
16	1.2	2.2	2.2
18	1.1	2.2	2.2
20	1.0	2.2	2.2
22	.9	2.2	2.2
24	.9	2.1	2.2
26	.9	2.1	2.2
28	.9	2.1	2.2
30		2.0	2.2

TABLE 9. -- *Diameter growth (wood and bark) of pine 5 year period, Jasper County sample area*

Diameter breast height	Old field loblolly pine			Old field shortleaf pine		
	Well stocked	Medium stocked	Poorly stocked	Well stocked	Medium stocked	Poorly stocked
			Inches			
2	2.55	2.80	2.80	1.50	1.65	2.00
4	2.75	2.90	3.00	1.55	1.65	2.00
6	2.70	2.70	2.90	1.40	1.65	1.85
8	2.45	2.45	2.80	1.30	1.50	1.70
10	2.05	2.20	2.50	.95	1.30	1.40
12	1.65	1.75	2.20	.75	.95	1.05
14	1.30	1.40	1.85	.65	.85	.95
16	.85	1.10	1.65	.40	.75	.75
18	.55	.85	1.40	.40	.60	.75
20	.45	.75	1.40	.40	.60	.70

Diameter breast height	Pine-hardwood type		Upland pine type	
	Loblolly pine	Shortleaf pine	Loblolly pine	Shortleaf pine
		Inches		
2	1.85	1.00	1.55	1.00
4	1.90	1.00	1.50	1.00
6	1.90	1.00	1.50	.95
8	1.90	1.00	1.45	.95
10	1.90	1.00	1.45	.95
12	1.90	1.00	1.45	.90
14	1.90	1.00	1.45	.90
16	1.90	.95	1.40	.90
18	1.85	.95	1.40	.90
20	1.75	.95	1.40	.90
22	1.65	.95	1.40	.90

FOREST INDUSTRIES

LUMBERING

Small mills have sawn nearly all the timber that has ever been cut in the Lower Piedmont Region of Georgia. Since the beginning of the World War, when many of these small sawmills began cutting, the principal product has been pine boards or "roofers", although small quantities of pine and hardwood dimension have also been cut, chiefly for local consumption. "Roofers", a trade name given to the pine boards, generally infers total millrun, which is mainly Number 2 common pine boards.

The usual lumbering set-up in this region consists of a planing mill and concentration yard, located in a town upon a main line railroad; and of several small sawmills in the woods, which cut and deliver the rough lumber to the planer. The sawmills, or "peckerwoods" as they are commonly called, are easily moved about to cut scattered tracts of timber. Both steam- and tractor-powered outfits are found. Their cut in an average day's run is from 3,000 to 10,000 feet board measure. At a steam sawmill (slightly larger than the average), cutting 7,000 feet board measure per day, eight men did the logging; eight others, the sawing; and three men, employed half time, hauled the rough lumber 14 miles to the concentration yard. Approximately one-third man-days were required at the planer per thousand feet planed and loaded on cars. A total of about 2.5 ten-hour man-days, or about 3 eight-hour days were required to produce 1,000 feet of "roofers."

The industry was active in 1929, and common wages in the sawmill were about $1.25 to $1.50 per day for common laborers, and $3.00 to $4.00 for the sawyer. "Roofers" sold for about $17.50 per thousand board feet. Second-growth pine stumpage sold for $2.50 to $3.50 per thousand board feet; virgin timber, for $5.00.

Sawmills in this section were operating less in 1932 than in any other year since the World War. "Roofers" sold at this time for an average price of about $7.50 per thousand board feet, loaded in cars; wages at the sawmills were generally 50¢ to 60¢ per ten-hour day for common labor and $1.50 for the sawyers. (At this time many farm laborers received from $5.00 to $7.00 per month, without board). Pine stumpage, on the basis of mill tally, sold for $1.00 to $2.00 per thousand board feet. At the operation previously outlined, the planing mill or concentration yard bought the timber stumpage for $1.00 per thousand board feet lumber tally; and paid $3.50 per thousand to a contractor for logging and sawing, and $1.50 per thousand for hauling the rough lumber to the planer. Total cost to the planer was $6.00, leaving $1.50 for planing, loading, and selling. This work provided jobs, but very low wages and very little profit.

As a result of the lumber industry's having adopted the Code of Fair Competition in 1933, common wages are 24¢ per hour, and Number 2 common boards have a minimum price of about $20.00 per thousand board feet at the mill. Pine stumpage is about $2.50 per thousand board feet. Since the Code became effective, wages have been raised 380 percent above the low levels existing in 1932 and the first half of 1933. Because wages and salaries account for about 44 percent of the total manufactured value of lumber and timber products for the entire southern pine industry,[1] a commensurate rise in the price of lumber was expected.

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[1] Wackerman, A.E. and Spillers, A.R. "Labor Versus Machinery, etc.", *Southern Lumberman*, 46 (1853): 21-23, June 1933.

In January 1934, 220 sawmills in the Lower Piedmont Region of Georgia were allotted production quotas under the Lumber Code. The total allotment amounted to 14,128,000 board feet. Allowing three man-days for logging and manufacturing 1,000 board feet of lumber, the cutting of this allotment would have furnished 42,384 man-days of employment per month. If the allotment had been cut at a minimum wage of $1.92 per eight-hour day (a certain percentage of the men, however, would have been employed as skilled laborers at more than minimum wages), the wages paid out would have totaled about $85,000 per month.

FUELWOOD PRODUCTION

Farmers sold large quantities of fuelwood in 1932 for consumption by small industries and homes. Although soft coal was cheap, many of the cotton gins, cotton-seed mills, ice plants, and other industries used wood (the local product) to help the farmers whose usual incomes were greatly depressed. One cotton-seed mill manager stated that 10 cords of wood or 6 tons of bituminous coal were required to generate power sufficient for crushing 20 tons of cotton-seed. With cordwood selling for $2.25 per cord and coal for $3.50 per ton, the cost of milling with fuelwood was only about 7½¢ greater per ton of cotton seed. About 6 bales of cotton may be ginned per cord of wood.

Cordwood in 4-foot lengths sold in 1932 for $1.50 to $2.50 per cord, an average price of $2.00 delivered in town. This price allowed 50¢ per cord for cutting, $1.25 for hauling, and 25¢ for stumpage. Fireplace wood in 1½- and 2-foot lengths sold for about $3.00; stovewood in 14-inch lengths sold for about $4.00 per cord. Approximately 1.5 man-days are required for cutting a cord of stovewood, while one man-day is needed for fireplace wood. An average of 12 cords of wood are used annually on the farms for heating and cooking purposes. A few posts and sawlogs also are cut occasionally for farm home needs.

OTHER WOOD-USING INDUSTRIES

Only small quantities of wood are used for purposes other than lumber or fuel. A mill at Monticello, Georgia, manufactures bobbins and shuttles, but the raw material is shipped in from other regions. Beech, birch, and hard maple are used for bobbins, and dogwood and persimmon for shuttles. In 1929 this plant employed 45 people full time at an average wage of $2.00 per day, but in 1932 it operated only two-thirds of the time with 25 people, each of whom received about $1.25 per day.

A small volume of white and red oak stumpage in trees of merchantable size occurs in scattered tracts, usually along the branches. If this timber is sound and is 18 inches or larger in diameter, it is suitable for staves for tight cooperage. In 1932, a limited number of staves, to be used in the manufacture of barrels for beer, wine, and whiskey, were prepared in this region for the export trade. They were hand-rived by a crew of three men, who cut from 200 to 250 staves per day. Although four different sizes are made, the bolts, when dry, are usually 4½ inches wide, 2 inches thick, and 4 feet long. White oak staves sold f.o.b. for 10¢ each and red oak staves for 7¢ each; about 40 percent of this price was said to have been paid for stumpage. Great impetus has been given to the production of staves since the repeal of the Eighteenth Amendment, so that prices and wages have risen accordingly. The stumpage volume of high quality oak, however, is so small that it prevents a widespread development of the oak-stave industry in this region.

The forest resources of the region, if properly managed, could no doubt support additional wood-using industries. These industries would have to depend for some time upon poor quality second-growth timber, but with forest management the quality and quantity could be greatly improved and increased.

* * *

FINANCIAL POSSIBILITIES OF FOREST MANAGEMENT IN PRESENT FOREST STANDS

Present Production of Forests

The preceding chapters have shown that about two-thirds of the total forest area of the Lower Piedmont Region is in old field pine stands, and that most of these stands are understocked and composed of a poor quality of timber. The same is true of other than old field stands. This deficiency of good sawtimber is owing chiefly to the fact that farmers have been forced to strip their forest lands of salable timber when farm crops have failed to yield the necessary cash requirements. The small number of wood-using industries and the small volume of lumber cut in the region at present, as compared to the very active lumber industry during the late 1920's, are the direct effects of this scarcity of sawtimber.

Forest management under these circumstances does not promise immediate profits of much consequence. In order to obtain satisfactory profits in forest management, the growing stock in large trees (17 inches and over d.b.h.) must be built up. Moreover, the quality of the timber must be improved by increasing the density of stands. Such improvements can be attained in future stands by protecting the abundant natural reproduction against fire and by limiting the cut to only the largest sawtimber trees and the poor quality trees. Hardwoods, which come in after cutting, aid materially in naturally pruning the pines and in improving the site.

Estimated Future Yields of Forests Under Management

Since it is impossible to account for the many factors that may influence volume growth, the prediction of future yields of forests under management for longer than 5 or 10 year periods, even though it be based on the most careful measurements of growth and mortality, cannot be accurate. The increment of well stocked sawtimber stands is a fair indication of what can be expected from the understocked stands after they have been built up under forest management. But even the well stocked sawtimber stands of this region are at present understocked in the large diameter classes; hence their average yearly increment of 265 board feet per acre in the six sample areas is low. The yearly increment in this class of stand in the Wilkes Pistol sample area was 432 board feet per acre. The average volume per acre of twenty of the best stocked mature timber plots taken on the line plot survey in the region was 20,383 board feet (International one-quarter inch kerf rule) in trees over 13 inches (d.b.h.) The average age of these stands was 65 years, but the present annual increment was not determined. Judging by these data, it is not unreasonable to expect average volumes of at least 10,000 board feet per acre in sawtimber trees, and annual increments of at least 500 board feet per acre after the stands have been built up under intensive sustained yield management. Such an increase in volume will materially improve the quality of the material, and these two factors will in turn greatly increase the value of the yield.

REGULATED CUTTING

Little thought is given at present to the growing of crops of timber in this region, where the forest has always been exploited. In planning forest management, the owner's immediate financial requirements must be considered; but the conservation of capital values should not be lost sight of. The cut must be limited to the annual growth if a sustained yield or a perpetual income from forest property is desired; and the forest growing stock must be built up to include a proper distribution of tree sizes, so that as the large, old trees are cut, smaller and younger ones grow up to take their places. Most of the stands in this region are made up chiefly of trees below sawtimber size which, if properly managed, will have a much greater annual growth, or increment, in a few years than they have now. The quality of the timber can be improved by cutting out undesirable trees; besides, the land owners need a current cash income. For these reasons, during the next 5 or 10 years it would be desirable to cut the increment of sawtimber 13 inches and over (d.b.h.), but the cut should not exceed this increment.

Numerous studies have shown that large trees not only yield more valuable forest products than small ones, but also that they cost less per unit to log and saw. It is essential that the growing stock of the present forests be built up so that financially mature trees can furnish the current yield and provide for future cuts. Along with harvest cutting of sawtimber trees, stand improvement work should be carried on to improve the growing stock. Trees not suited for future growth, such as rough trees, large over-topping trees, and thinning material, should be removed if their removal will pay for itself.

A selection system of cutting, under which groups of trees as well as single trees are removed, is suitable for both old field and natural forest stands in this region. Although stands can be cut over annually, it is usually more economical to cut once every 5 or 10 years in order to get a heavier cut per acre. Inventories almost invariably show that stands are better stocked in the small diameter classes than in the sawtimber sizes, and that natural reproduction comes in abundantly. The allowable cut of sawtimber volume depends upon stand increment. In determining this allowable cut, however, only the increment of trees over 13 inches (d.b.h.) need be considered, since these are the trees that will be removed either in the present cut or in a later one. The annual cut should not exceed the sum of the net current growth of these trees on all parts of an ownership.

In order to determine the annual growth, or increment, of the stand, it is necessary to determine the diameter growth, and then to apply this diameter growth to the trees in the stand. The volume of the present stand subtracted from the volume of the stand after one year's growth (in diameter and height) gives the volume growth for one year. The farm woodland owner or other woodland owner may require the assistance of the State Forester or the State Extension Foresters in making these calculations. If such assistance is not available, the application of the annual volume growth found and reported in this bulletin for stands similar to those under consideration may be made without serious error. The annual growth of sawtimber (trees 13 inches and over d.b.h.) found in this region amounts roughly to 10 percent of the board foot volume in old field pine stands and 5 percent in other stands. If the landowner, in determining the allowable cut, applies these percentages to the volume in his stands, and then limits the cut to high grade sawtimber trees (17 inches and over d.b.h.) and to other trees that should be removed to improve the stand, he will be handling his timber in a manner consistent with good forestry practices.

Large forest properties should be subdivided into permanent management units. The trees should be carefully selected and marked before cutting. Sufficient high quality large trees should be taken in the first cut to obtain a fair income, but the aim should be to leave the most valuable species and the best formed trees so that productivity in quantity and quality might be built up and the largest future earnings assured. The present market for stumpage utilizes poor quality field timber. When marking for sustained yield on large forest properties, a tally should be made of all trees 13 inches and larger (d.b.h.) that are to be cut, and a separate tally of those trees over 13 inches that are to remain. The first tally will make sure that the marking does not include a volume exceeding the present increment; the second tally will indicate the approximate future increment and cut. The cost of such marking and inventory runs about $0.05 per thousand board feet in fairly well stocked sawtimber stands, or about $0.20 per acre. Between 40 and 60 acres can be covered by a crew of three or four men in an eight-hour day.

FIRE PROTECTION

Fire control is one of the first requirements of forest management. The line plot surveys in the six sample areas showed that 14.8 percent of the forest land burned over in 1932. On small holdings, such as a farm woodland, fire protection may mean nothing more than constant vigilance and the prompt extinction of fire when it does occur. Large properties, however, require a carefully planned detection system of well-placed look-out towers, a well organized system of fire and telephones lines, and a thoroughly trained detection and suppression force. Intensive protection of large areas has been found to cost about $0.05 per acre per year.

PLANTING

While natural reproduction can be depended upon where seed trees are now present, certain areas of idle land and cut-over areas lack seed trees and therefore require planting in order to produce a forest. Approximately 40 plantations of forest trees were visited in 1933 in the Lower Piedmont Region of Georgia. The oldest loblolly pine plantation was established in the spring of 1927. After 6½ growing seasons the survival was over 95 percent; the average height, 19 feet; and the maximum height, 21 feet. Some of the trees measured 5 inches or slightly more in diameter at breast height. The oldest slash pine plantations visited were established in 1931. After 2½ growing seasons the average height of the slash pines was 2 to 4 feet; the maximum height, about 6 feet. The oldest black locust plantation was planted in 1923. On a poor site this species had a survival of 98 percent, a maximum height of 40 feet, and a maximum diameter at breast height of 6 inches.

Additional information on plantations may be obtained from the data shown in table 2 in the Appendix. In general, the following conclusions may be drawn:

1. - Loblolly and slash pines have been the most favored species for planting; but longleaf pine, black locust, yellow poplar, and red cedar are sometimes used.

2. - Plantations are generally established upon old fields, and the area in plantations of individual ownership is usually about 1 to 10 acres; some are 20 acres or larger. The planting sites are often eroded slopes upon which the soil is poor and the drainage excessive.

3. - The trees were usually set in February at 6-foot intervals in plowed furrows spaced about 8 feet apart. Spacings 6 x 6 and 6 x 7 feet were also found.

4. - The cost of establishing plantations was extremely low because the stock was furnished usually by the Georgia State College of Forestry at Athens for $1.50 to $2.50 per thousand, and most of the planting work was done by farm labor at $0.50 per day. Total cost was about $2.00 to $3.00 per acre.

5. - Survival was good in most of the plantations studied, even though some were upon poor, dry, eroded sites. The greatest survival percent was often found where the vegetation was sparse and where sheet erosion had removed much of the top soil. The fastest growth was often found in the bottom of the washes or shallow gullies, probably because greater moisture is available there than upon the slopes. Good survival but relatively poor growth were found in deep gullies and on steep slopes. Seedlings could not survive at all in the few places where erosion was most active, unless grasses and other vegation helped the trees to arrest it and protected the seedlings from washing out or silting over.

6. - Loblolly pine and black locust seem to give the most satisfactory results in planting. Mixed rather than pure plantings of these species are the more satisfactory; for in managing mixed stands, it is possible to harvest the locust for posts after 13 years, thus leaving thinned the remaining stand of pine. Insect pests attack both species: the tip moth, the pine; and the locust borer, the black locust. What little damage they caused in this region, however, was confined to pure, densely planted stands.

7. - Although this region is north of the natural range of slash pine, that species may prove excellent for planting purposes. Slash pine plantations established here to date are not yet old enough to prove the feasibility of planting that species; but after two growing seasons it was making excellent growth even upon poor, dry sites. Slash pine, yellow poplar, red cedar, and other species should not be planted in large tracts until the present plantations or subsequent small ones are old enough to demonstrate the adaptability of these species to different sites. Although no plantations of shortleaf pine were found (possibly because it is not as favored as some of the more rapidly growing species), this species is adapted to growing upon the poor sites of the region, and its hardiness makes it valuable for erosion control and for lumber or pulpwood production.

Taxes

Taxes must be paid each year whether or not the cleared land or the woodland produces an income. The assessors do not, as a rule, recognize the timber volume present in the stand. According to a study of this region made by the Bureau of Agricultural Economics of the Department of Agriculture, cultivated, idle, and forest land are assessed identically for real estate taxes. The two main factors that govern the evaluation of land are the buildings and other improvements, and the availability of good roads. The rates of assessment and taxes per acre were found to vary somewhat in different counties; they also varied as to the owner's residence and the size of his property. Table 10 shows the assessed value and taxes per acre, as obtained by the Bureau of Agricultural Economics for each of the five counties in which sample units were studied, in relation to residence of owners and to size of holdings, as well as the averages for the five counties.

This study of taxes and ownership in the Piedmont Region shows that 80 percent of the total area of the region is held by owners that reside in the county in which their land lies, or in the county adjacent thereto; that 16 percent is held by owners that reside in the state, but outside the county or adjacent county; and that 6 percent is held by owners that reside outside the state. Land belonging to residents outside

Table 10. - Assessed value and taxes per acre in five counties in the Lower Piedmont Region of Georgia

	Jasper		Monroe		Wilkes		Meriwether		Morgan		Average	
	Ass'd. value	Taxes	Ass'd. value	Taxes	Ass'd. value	Taxes	Ass'd. value	Taxes	Ass'd. value	Taxes	Ass'd. value	Taxes
						$						
Residence of owner												
County or adjoining county	3.32	.089	4.68	.119	4.74	.123	4.55	.133	6.64	.147	4.79	.122
State but outside of county or adjoining county	2.92	.075	5.04	.128	4.90	.133	4.38	.126	6.72	.149	4.79	.122
Outside of state	3.20	.085	5.08	.128	4.41	.112	5.82	.170	7.61	.169	5.22	.133
Size of property Acres												
2 - 49*	3.77	.115	60.54	1.532	13.01	.379	6.02	.164			16.67	.438
50 - 174	2.93	.084	4.72	.119	5.74	.155	5.14	.148	6.55	.155	5.02	.132
175 - 499	3.57	.111	4.49	.114	4.80	.127	4.81	.139	7.16	.164	4.93	.131
500 - 999	3.12	.084	4.92	.125	4.85	.129	4.81	.138	6.84	.150	4.91	.125
1000 - 1999	3.24	.081	4.44	.112	4.70	.117	4.29	.129	6.73	.149	4.68	.118
2000+	3.07	.077	4.16	.105	3.77	.100	4.37	.130	6.19	.136	4.31	.110

* Assessments in this class often include especially valuable properties, as exemplified in Monroe county.

the state is usually assessed slightly more than that of residents living on or near their properties. The study also showed the following percentages of total area falling in each size of holding:

Acres	*Percent of total area*
2 - 49	2.9
50 - 174	25.7
175 - 499	32.9
500 - 999	16.8
1,000 - 1,999	11.4
2,000 & over	10.3

Per-acre assessments for large properties seem to be a little less than those for small ones.

FINANCIAL POSSIBILITIES OF FARM WOODLANDS

Farm woodlands in the Lower Piedmont Region contribute to the cash income from the farm; they also furnish the fuel supply for the home, and the fence posts and other wood products needed for farming. In order to show present forest conditions, increment, and financial possibilities of farm woodlands in the Lower Piedmont Region, a typical farm mapped in the Meriwether sample area has been selected. A study of size of ownership made in 1932 by the Bureau of Agricultural Economics, U. S. Department of Agriculture, revealed that the 175 to 499 acre class contained the largest acreage of farm land in this county, as well as in the whole region. The farm selected has a total area of 297 acres, of which 230 are forested and 17 are idle land, suitable for forests but not for agriculture. Cultivated land makes up 37 acres; idle land suitable for agriculture, 13 acres. The forest woodland is made up of the following classes of stands: Sawtimber old field pine, 88 acres; young old field pine, 72 acres; pine hardwood type along the branches, 32 acres; upland pine type on a ridge, 18 acres; and bottomland hardwood along the creek, 20 acres. (For definitions of types and classes of stands, see pages 5 to 7). The proportion of area in each class approximates that found in the Meriwether sample area closely enough to render the farm a good example of the sample area as a whole. The areas occupied by stands of different densities in old field stands, and by sawtimber and young stands in the pine types other than old field, could not be mapped because they are too closely intermingled. These areas on the farm were derived by applying the same proportions of each as those determined by the line plot survey on the sample unit. Table 11 shows the area of each class of stand in the farm woodland.

The merchantable pines in all types range from 13 inches to about 20 or 22 inches but the majority are in the lower diameters. Many of these trees are limby and of poor quality, especially in the old field pine stands. Pines growing with hardwoods in natural forest stands are of much better quality.

Table 11 applies volumes and annual increments found in the Meriwether sample area to the stands in the farm woodlands. This table shows a total annual increment of 22,670 board feet of pine and 5,613 board feet of hardwoods in trees over 13 inches (d.b.h.). The annual increment in well stocked old field pine sawtimber stands is 237 board feet of pine per acre, whereas that of poorly stocked old field stands is 97 board feet of pine. Sawtimber stands in the pine hardwood type have an annual volume growth per acre of 139 board feet of pine and 105 board feet of hardwoods; those in the upland pine type, 120 board feet of pine and 39 board feet of hardwood. Bottomland hardwoods, from which most of the merchantable trees have been cut, are

Table 11. - Areas, volumes, and annual increment of sawtimber over 13", diameter breast height, in a farm woodland in the Meriwether sample area

Class of stand	Area	Volume				Annual increment			
		Per acre		Total		Per acre		Total	
		Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	Acres	Board feet							
Old field pine type:									
Sawtimber well stocked	40	3,339		133,560		237		9,480	
Sawtimber medium stocked	35	1,780		62,300		185		6,475	
Sawtimber poorly stocked	13	1,435		18,655		97		1,261	
Young well stocked	27	35		945		15		405	
Young medium stocked	21					17		357	
Young poorly stocked	24	41		984		10		240	
Pine hardwood type:									
Sawtimber	24	2,274	2,106	54,576	50,544	139	105	3,336	2,520
Young	8	284	2,901	2,272	23,208	29	145	232	1,160
Upland pine type:									
Sawtimber	7	3,167	778	22,169	5,446	120	39	840	273
Young	11	35	1,199	385	13,189	4	60	44	660
Bottomland hardwoods	20		996		19,920		50		1,000
Totals	230			295,846	112,307			22,670	5,613

annually growing only 50 board feet per acre. These per-acre sawtimber volumes indicate that the growing stock is low. The maximum volume of pine, 3,339 board feet per acre, occurs in well stocked old field stands. If properly stocked, this stand should have more than double that volume of sawtimber. Virtually all stands need to be built up, especially in the larger diameters.

The total cut in this farm woodland during the next 5 years should not exceed the present annual increment. With the majority of the trees in the small diameter classes, this annual increment would thereby increase during the 5 year period, so that by holding the cut at the present increment the stand itself would increase. Moreover, in cutting this increment, as much of the cut as possible should come from poor quality trees that are not desirable for future growth. As many high quality trees as possible should be left for future cuts, but in order to obtain sufficient volume the largest trees of both high and low quality must be taken. One reason for leaving the high quality trees for a future cut is that owing to the large percentage of present sale volume in low quality lumber, no price distinction is made in favor of higher quality products. The price commonly paid for stumpage is about $2.50 for pine and $2.00 for hardwoods, measured in lumber stacked after sawing. The total value of the allowable cut of sawtimber, which equals the present increment, is therefore $56.68 for pine stumpage and $11.23 for hardwood stumpage. Table 12 gives the value of the present annual increment of sawtimber for each class of stand. This value varies from $0.59 per acre for well stocked old field pine sawtimber stands to $0.24 per acre for those that are poorly stocked. The value of the annual increment of sawtimber pine-hardwood stands is $0.35 per acre for pine stumpage and $0.21 for hardwood stumpage, a total of $0.56. In upland pine sawtimber stands, the per acre value of annual pine increment is $0.30; that of hardwood, $0.08. As volume and quality of timber improve, correspondingly these values will increase. Owners can augment their cash income by doing their own logging and by selling the logs at the roadside or at the sawmill.

The first cut of sawtimber, designed to remove 28,283 board feet of pine and hardwood, should cover one-fifth of the sawtimber areas. Where sawtimber and young stands are intermingled, however, as in the pine-hardwood and upland pine types, it will be necessary to cover one-fifth of the total area of these types. Table 13 gives the areas, volumes, and stumpage values included in this first cut of sawtimber. Each cut made annually during the succeeding four years will cover an area and remove a volume of wood about equal to those of the first cut, thus completing at the end of five years the first cutting cycle, during which all sawtimber stands will have been cut over. During several subsequent cutting cycles, approximately the same volumes will be cut from the same areas; but inasmuch as the stands are meanwhile building up, especially with more trees of sawtimber size and quality, eventually both the volume of the annual cut and the area covered can be increased. Volumes of future cuts, made each 5 years in stands that have been grown under management, should, on a per-acre basis, equal at least the 5 years' increment of present well stocked stands; these volumes will probably amount to between 2,000 and 2,500 board feet per acre.

Table 13 also shows the quantity of fence posts and fuelwood that can be cut from tops of sawtimber trees and from improvement cuttings and thinnings. The volume of fuelwood available from tops of sawtimber trees amounts, approximately, to one-quarter cord of pine and one-half cord of hardwood per 1,000 board feet of pine and hardwood saw logs respectively; an equal proportion is available from trees removed in stand improvement, thus making a total cut of one-half cord of pine and one cord of hardwood to 1,000 board feet of pine and hardwood. Only 27 acres, or 37.5 percent of the entire 72 acres in the young stands of old field pine, are stocked sufficiently to need a thinning. If one-fifth of the total area in young stands, (14.4

acres) is covered the first year, then only 37.5 percent, (5.4 acres) is dense enough to thin. In order to liberate crop trees, which will make up future sawtimber cut, about one cord of fuelwood and 10 fence posts per acre will be cut as thinnings from

TABLE 12. -- *Volume and stumpage value of annual increment of sawtimber over 13 inches, d.b.h., in a farm woodland in the Meriwether sample area*

Class of stand	Area	Annual increment per acre				
		Volume		Value		
		Pine	Hardwood	Pine[1]	Hardwood[2]	Total
	Acres	*Board feet*[3]		*Dollars*		
Old field pine type:						
Sawtimber well-stocked	40	237		.59		.59
Sawtimber med. stocked	35	185		.46		.46
Sawtimber poorly stocked	13	97		.24		.24
Young well-stocked	27	15		.04		.04
Young med. stocked	21	17		.04		.04
Young poorly stocked	24	10		.02		.02
Pine hardwood type:						
Sawtimber	24	139	105	.35	.21	.56
Young	8	29	145	.07	.29	.36
Upland pine type:						
Sawtimber	7	120	39	.30	.08	.38
Young	11	4	60	.01	.12	.13
Bottomland hardwoods	20		50		.10	.10

[1] Pine stumpage at $2.50 per thousand board feet.

[2] Hardwood stumpage at $2.00 per thousand board feet.

[3] International 1/4-inch kerf rule.

Table 13. - Annual cut of sawtimber, fence posts and fuelwood on a farm woodland in the Meriwether sample area

Class of stand	Area cut	Sawtimber									Fuelwood		Fence posts	
		Volume				Stumpage value								
		Per acre		Total		Per acre		Total						
		Pine	Hdwd.	Pine	Hdwd.	Pine[1]	Hdwd.[2]	Pine	Hdwd.	Total	Pine	Hdwd.	Pine	Hdwd.
	Acres	----- Board feet [3] ----				--------------- $ ---------------					-- Cords --		--Number--	
Old field pine type:														
Sawtimber	17.6	1,035		18,218		2.59		45.55		45.55	9.1			
Young	14.4										5.4		54	
Pine hardwood	6.4	558	575	3,568	3,680	1.39	1.15	8.92	7.36	16.28	1.8	3.7		
Upland pine	3.6	246	259	884	933	.61	.52	2.21	1.87	4.08	.4	.9		
Bottomland hardwoods	4.0		250		1,000		.50		2.00	2.00		1.0		100
Total	46.0			22,670	5,613			56.68	11.23	67.91	16.7	5.6	54	100

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[1] Pine stumpage at $2.50 per thousand board feet.
[2] Hardwood stumpage at $2.00 per thousand board feet.
[3] International 1/4" kerf rule.

the 5.4 acres. From the 4 acres in the bottomland hardwoods that are being cut for sawtimber, 25 hardwood fence posts per acre will be cut from low quality trees. This cut of fuelwood and fence posts can probably be maintained in future cuts. At present there is no market for pulpwood in this region; and because of the low value of fuelwood, the labor cost of producing it virtually equals its present sale value. The owner of this farm will use 12 of the 22 cords of fuelwood cut; he can sell the remaining 10 cords for about $2.00 per cord delivered. If he hires a wood cutter, he will come out even; but if he cuts and delivers the wood himself, he will receive $20.00 for his efforts.

The owner of this farm woodland can therefore place it under sustained yield management without spending any cash over and above his present expenditures. His annual taxes amount to about $0.14 per acre as usual; but his fire protection cost amounts to nothing more than an average of 3 days a year spent in fighting fires that threaten his property. By educating his neighbors concerning fire damage he can even reduce that cost.

Before cutting, the different classes of stands should be subdivided into 5 areas, each of about the same acreage, and boundaries should be blazed out. The cut for the first year would then be limited to one area in each class of stand. Subdividing will require of the farmer and his helper about three days' time. Three more days' time of two men, including two-thirds of a day with a truck, will be required to cut and haul 5.4 cords and 54 fence posts, the thinnings from 5.4 acres scattered over 14.4 acres. These thinnings should remove only the trees that are crowding out the previously selected crop trees, spaced from 10 to 15 feet apart. An additional day's work for two men will be required to cut and deliver the 100 hardwood posts from the bottomlands. Two men will need about two days to mark the trees for harvest and improvement cuttings, and to take an inventory of sawtimber trees on the 31.6 acres to be covered the first year. Technical help in marking can be obtained by applying to the State and Extension Foresters. The purchaser of the 28,283 board feet of stumpage will require approximately the following men, equipment, and time for logging and hauling: Two men felling and bucking for 7 days; one man and team loading for 7 days; and one man and truck hauling for 7 days. The farmer and his helper can then come in after the logging and cut the discarded tops, as well as the trees they intend to fell for improvement cuttings, into fuelwood; this work will require 5 days and will produce 16.9 cords of fuelwood. The two men will need two more days to deliver 10 cords to town and 6.9 cords to the farm house.

This farm has 17 acres of idle land, unfit for agriculture, which should be planted to loblolly, black locust, and a few miscellaneous species. It is proposed to plant one-fifth of the area, or 3.4 acres, during the first of the five years. Seedlings can be purchased from the State at about $2.00 per thousand. If planted about 6 x 7 feet, or 1,000 to the acre, the area will require 3,400 seedlings at a total cost of $6.80. To plant an acre with this spacing requires about 1.5 man-days, or 5.1 man-days for the 3.4 acres. The farmer can do this work himself. Table 14 shows the detailed possibilities of such a plantation.

The following outline shows the operations, with costs and incomes, which the owner will carry out in putting the farm woodland under sustained yield management.

1. Subdivision of woodland into 5 areas, one of which is to be cut each year.
    - (*a*) Cost: 3 days' time of 2 men, or 6 man-days. This is not an annual requirement; it is done only once.
    - (*b*) Income: None.

2. Inventory and marking of trees to be cut in the first cutting area of 31.6 acres.

   (*a*) Cost: 2 days' time of 2 men, or 4 man-days.
   (*b*) Income: None.

TABLE 14. -- *Costs and returns per acre from planting*

Date	Work	Cost	Stumpage returns
1935 or first year	Plant 1000 trees 6 x 7 feet in mixtures generally involving 400 black locust, 400 loblolly, and 200 miscellaneous, including shortleaf, red cedar, and yellow poplar.	Planting labor 1½ man-days; planting stock $2.	
1945 or tenth year	Survival is 80% and trees average 3 inches at d.b.h. Thin, leaving 500 trees per acre (200 locust, 200 loblolly pine, 100 miscellaneous).	1 man-day per acre.	
1955 or 20th year	Allowing for mortality and growth there will be 450 trees averaging 6 inches. Thin by removing the 180 remaining locust. 270 trees are left.		180 locust trees or 360 posts.
1965 or 30th year	Allowing for mortality and growth there will be 240 trees with an average size of 10 inches. Cut 140 trees leaving 100.		140 trees averaging 50 ft. b. m. per tree, or 7000 at $2.00 per M - $14.00.
1985 or 50th year	Allowing for mortality and growth there will be 90 trees with an average size of 17 inches. Cut 60 trees leaving 30.		60 trees averaging 270 ft. b. m. per tree, or 16,200 at $4.00 per M - $64.80.
1988 or 53rd year	Cut the remaining 30 trees averaging 18 inches. In last three years natural young growth will have become established at no cost.		30 trees averaging 310 ft. b. m. per tree, or 9,300 at $4.00 per M - $37.20
	Taxes for 53 years at $.14 per acre (without interest)	$7.42	
	Total in 53 years Net income per year (without interest)	$9.42	$116.00 $2.01

3. Sale of sawtimber stumpage from 31.6 acres.

   (*a*) Cost: None.
   (*b*) Income: 22,670 board feet of pine stumpage at $2.50 per thousand board feet; 5,613 board feet of hardwood stumpage at $2.00 per thousand board feet--a total cash income of $67.91.

4. Thinning of young stands on 14.4 acres of old field pine.

   (*a*) Cost: 3 days' time of 2 men, or 6 man-days; and use of a truck for two-thirds of a day.
   (*b*) Income: 5.4 cords of fuelwood used on the farm; 54 pine fence posts.

5. Improvement cuttings and cutting of tops into fuelwood on 31.6 acres.

   (*a*) Cost: 8 days' time of 2 men, or 16 man-days; and 2.5 days' use of truck.
   (*b*) Income: 10 cords of wood sold for $20.00 cash; 6.9 cords of wood used at the farm house; and 100 hardwood fence posts used on the farm.

6. Protection against fire of 230 acres of woodland and 17 acres of idle land to be planted to forest trees.

   (*a*) Cost: 3 days' time of 1 man fighting fire, or 3 man-days.
   (*b*) Income: None.

7. Planting of 3.4 acres of idle land annually for 5 years.

   (*a*) Cost: 3,400 seedlings at $2.00 per thousand - $6.80; 1.5 man-days per acre, or 5.1 man-days.
   (*b*) Income: No income for about 20 years, or until fence posts and fuelwood may be cut.

8. Payment of taxes on 230 acres of woodland and 17 acres of idle land to be planted to forest trees.

   (*a*) Cost: $0.14 per acre, a total of $34.58 per year.
   (*b*) Income: None.

Since the farmer and his family can do most of the work required to put the farm woodland under management, cash charges for labor need not be set up; on the other hand, since many of the products cut are used on the farm rather than sold, cash values need not be applied to them. The only cash costs are taxes, $34.58, and tree seedlings, $6.80; the cash incomes are stumpage, $67.91, and fuelwood, $20.00. The net cash income for the year considered is $87.91 less $41.38, or $46.53. The cost of gasoline and depreciation against the truck are also to be considered, but the farmer can often deliver his wood when making a necessary trip to town for another purpose.

If those annual activities of the owner that yield no income--such as fire protection (3 man-days valued at $6.00); marking and inventory work (4 man-days valued at $8.00); cutting and hauling the 10 cords of wood (time of men and truck valued at $20.00)--are charged against the income along with taxes and cost of pine seedlings, then the net income is $87.91 less $75.38, or $12.53. It must be remembered, however, that the farm woodland has now been put into condition for more volume and better quality growth. Unquestionably, the annual yield of stumpage from this forest can be increased at least three, probably four or more times in volume, and still more in value. If the farmer does his own logging and transports the logs to the sawmill, he will need 28 man-days of labor, 7 days' use of his team, and 7 days' use of a truck; but he can obtain about $6.00 per thousand board feet for logs delivered at the mill, or a total of $169.70 instead of $67.91, the present stumpage price.

In addition to these tangible values in timber products which the farm woodland provides, it also prevents serious erosion of land, serves as a pasture for live stock and a habitat for wild game, and has important recreational value.

FINANCIAL POSSIBILITIES OF SUBSISTENCE HOMESTEAD COMMUNITY FORESTS

A subsistence homestead project has been proposed for Jasper County, Georgia. A community forest has been considered as a part of this undertaking, and it is desirable to know the financial possibilities of such a forest. In order to illustrate these possibilities, a hypothetical 10,000-acre forest has been set up, which has the same proportion of forest types, classes of stands, and idle land suitable only for forests as were found in the Jasper County sample area (8,700 acres). The volumes, annual increment, and other forest data found in this unit have also been adopted. Cultivated land and idle land suitable for agriculture have not been considered for forests, since they will be used for cultivation.[1]

This forest of 10,000 acres is made up of 8,670 acres of forests and 1,330 acres of idle land, which is potential forest land as it is unsuitable for agriculture. It consists of 5,980 acres of old field pine; 870 acres of pine and hardwoods that grow along the second bottoms of the larger streams and along branches; 780 acres of pine and hardwoods that grow on the ridges; and 1,040 acres of hardwoods in the bottom lands of the larger streams. The potential forest land consists of abandoned fields and pastures, which are unsuitable for agriculture because of erosion, steepness of slope, or poor soil quality.

The areas, volumes, and annual increment of sawtimber of each class of stand within the forest types are shown in table 15. (See pages 5 to 7 for definitions of forest types and classes of stand; stand tables for each class of stand are shown in tables 6 and 7). The total annual increment of sawtimber (trees over 13 inches, d.b.h.) in present stands is 707,330 board feet of pine and 352,210 board feet of hardwoods. It so happens that the present annual increments in the three classes of sawtimber stands in the old field pine type do not vary greatly because the heavier densities of the better stocked stands are in the small diameters, which do not enter into the sawtimber increment at present. The maximum annual increment in old field pine is 243 board feet per acre, and the maximum present volume of sawtimber is 2,852 board feet. Pine hardwood sawtimber stands have an annual increment of 122 board feet of pine and 96 board feet of hardwood per acre on a volume of 1,805 board feet of pine and 1,917 board feet of hardwoods. Upland pine sawtimber stands have an annual increment of 83 board feet of pine and 117 board feet of hardwoods per acre, and a volume of 2,584 board feet of pine and 2,343 board feet of hardwoods. Bottom hardwoods are growing 162 board feet on a volume of 3,236 board feet. Almost all stands are understocked in the sawtimber diameter classes, particularly the old field and open stands, and much of their volume is in poor quality timber that will saw out no better than Number 2 common boards.

To obtain an annual income and also to improve the stands so that they will yield a larger volume of higher quality material, it is desirable to cover the entire forest once each five years, making thinnings, improvement cuttings, and harvest cut-

Table 15. - Areas, volumes, and annual increment of sawtimber over 13", diameter breast height, in a community forest in Jasper county

Class of stand	Area	Volume				Annual increment			
		Per acre		Total		Per acre		Total	
		Pine	Hardwood	Pine	Hardwood	Pine	Hardwood	Pine	Hardwood
	Acres	----------	----------	----------	Board feet	----------	----------	----------	----------
Old field pine type:									
Sawtimber well stocked	880	2,852		2,509,760		203		178,640	
Sawtimber medium stocked	1,070	2,186		2,339,020		243		260,010	
Sawtimber poorly stocked	720	939		676,080		198		142,560	
Young well stocked	1,070	16		17,120		5		5,350	
Young medium stocked	1,140	30		34,200		6		6,840	
Young poorly stocked	1,100	16		17,600		7		7,700	
								601,100	
Pine hardwood type:									
Sawtimber	470	1,805	1,917	848,350	900,990	122	96	57,340	45,120
Young	400	454	1,396	181,600	558,400	38	70	15,200	28,000
								72,540	73,120
Upland pine type:									
Sawtimber	330	2,584	2,343	852,720	773,190	83	117	27,390	38,610
Young	450		3,196		1,438,200	14	160	6,300	72,000
								33,690	110,610
Bottomland hardwoods	1,040		3,236		3,365,440		162		168,480
Total forested	8,670			7,476,450	7,036,220			707,330	352,210
Potential forest land now idle	1,330								
Total	10,000								

tings. Approximately one-fifth of the forest should be covered each year, and, in order to distribute the work as evenly as possible over the five year period, approximately one-fifth of the area in each stand class should be included, but the area to be cut should be blocked up as nearly as possible into one unit. Before beginning the cut, the areas to be cut should be located on the ground and the trees should be marked for cutting. A map based on aeroplane pictures that shows forest stand classes for the entire county will be available within a year; it will be of great assistance in planning and locating the cut on the property.

The total annual cut of sawtimber on one-fifth of the forest should not exceed the total present annual increment of sawtimber on the whole property. Since much of the growing stock is below sawtimber size, a large part of which is approaching sawtimber size, it is permissible to cut this present annual increment. Along with the logging, a considerable volume of fuelwood can be cut from tops of sawtimber trees and from trees cut in stand improvement. For every 1,000 board feet of pine logs cut on this property, about one-quarter cord of fuelwood can be cut from tops and another one-quarter cord from trees cut in stand improvement. Twice these amounts can be cut, namely, one cord of fuelwood, per 1,000 board feet of hardwood logs. On every four acres of bottomland hardwood, about 100 fence posts can be obtained in addition to the fuelwood. Fence posts can be cut also in thinning young stands of old field pine, but only one acre out of every three is dense enough to need thinning. On those areas with dense stands it is estimated that one cord of fuelwood and ten pine fence posts per acre will be cut in thinning. Table 16 shows the areas, volumes, and stumpage values included in the first cut of sawtimber by forest types; the number of fence posts and cords of fuelwood that will be cut from tops and in improvement cuttings; the areas of young stands in old field pine to be thinned; and the number of fence posts and cords of fuelwood to be cut.

The total annual cut of sawtimber, which is also the present sawtimber increment, is 707,330 board feet of pine and 352,210 feet of hardwoods. Since the present value of stumpage per thousand board feet is $2.50 for pine and $2.00 for hardwoods, the total value of pine stumpage is $1,768; that of hardwood stumpage, $704. But because one of the purposes of the subsistence homestead is to provide employment, it is not likely that this stumpage will be sold; probably it will be logged and manufactured into lumber by subsistence homesteaders, and possibly used by them in building homes, barns, and other necessary buildings. About 3 man-days of labor are required to produce 1,000 board feet of lumber; hence a total of 3,179 man-days would be required to cut the total volume. If the minimum lumber code wage of about $2.00 per day is paid, $6.00 per thousand board feet of lumber, or a total of $6,358 worth of labor, will have been provided. Wages make up about 50 percent of the total lumbering costs; if a sum approximately equal to the cost of labor is added for trucks, teams, depreciation of plants, and other overhead costs, the cost of the lumber before adding stumpage costs is $12.00 per thousand, or $12,715 total. The addition of the present current stumpage value of $2,472 brings the total cost of the lumber to $15,187, which is approximately $14.33 per thousand board feet.

Subsistence homestead farmers will also cut 706 cords of fuelwood and 5,200 fence posts from tops and from trees removed in improvement cuttings. Two men can cut approximately 3 cords of fuelwood or 150 fence posts per day, and 2 men with a truck can haul about 10 cords of fuelwood or 500 fence posts per day from the woods to the farm houses. To cut 706 cords of fuelwood, 471 man-days of labor are necessary; to cut 5,200 fence posts, 69 additional man-days are required. The hauling of fuelwood and fence posts combined consumes 162 man-days, 141 for the fuelwood and 21 for the posts. The total man-days of labor necessary for cutting and hauling amount to 702; at $2.00 per day, they represent $1,404 wages.

Table 16. - Annual cut of sawtimber, fence posts and fuelwood on a community forest in Jasper County

Class of stand	Area cut	Sawtimber									Fuelwood		Fence posts	
		Volume				Stumpage value								
		Per acre		Total		Per acre		Total						
		Pine	Hdwd.	Pine	Hdwd.	Pine[1]	Hdwd[2]	Pine	Hdwd.	Total	Pine	Hdwd.	Pine	Hdwd.
	Acres	------ Board feet[3] ------				----------------- $ -----------------					--Cords--		--Number--	
Old field pine sawtimber	534	1,126		601,100		2.82		1,502.75		1,502.75	301			
Old field pine young	662										221		2,210	
Pine hardwoods sawtimber and young	174	417	420	72,540	73,120	1.04	.84	181.35	146.24	327.59	36	73		
Upland pine sawtimber and young	156	216	709	33,690	110,610	.54	1.42	84.22	221.22	305.44	17	111		
Bottomland hardwoods	208		810		168,480		1.62		336.96	336.96		168		5,200
Total	1,734			707,330	352,210			1,768.32	704.42	2,472.74	575	352	2,210	5,200

1/ Pine stumpage at $2.50 per thousand board feet.
2/ Hardwood stumpage at $2.00 per thousand board feet.
3/ International 1/4" kerf rule.

The cutting and hauling of 221 cords of fuelwood and 2,210 pine fence posts removed in thinning 662 acres requires 229 man-days, 191 for the fuelwood and 38 for the posts; at $2.00 per day, this work involves a labor value of $458. To cut and haul a cord of fuelwood costs about $2.00--$1.33 labor cutting, $0.40 labor hauling, and $0.27 cost of the truck; the same cost for 100 fence posts is $4.00, or $2.67 labor cutting, $0.80 labor hauling, and $0.53 cost of the truck. For cutting and hauling fuelwood and fence posts in this community forest, the farmers will probably be reimbursed with fuelwood and fence posts at the cost price rate of $2.00 per cord for fuelwood and $4.00 per 100 fence posts.

Man-days required to cut lumber, fence posts, and fuelwood in harvest, improvement, and thinning cuttings during the first year total 4,110; the value of this labor is $8,220. Table 17 shows the distribution of labor in man-days, value of labor, other costs, stumpage values, and amount of forest products cut by operations. Although the lumber could probably be sold for an average price of $18.00 or $20.00 per thousand board feet, it would doubtless be good policy to sell it to the homesteaders at cost, $14.33 per thousand board feet, allowing credit for such labor as they contribute. The other forest products could be sold on the open market for about the cost of production, but they will probably be exchanged for labor contributed. The only net income from the forest with which to meet taxes, administrative costs, and other expenses is the stumpage value of the sawtimber cut--$2,472. Spreading this over 10,000 acres gives an annual income of about $0.25 per acre per year.

The annual costs on this community forest are for taxes, fire protection, inventory and marking, administration, and planting. No costs for roads or other improvements are included because it is understood that the county and state will bear costs of roads, and that workers on the forest will be housed on their subsistence homestead farms. Table 18 shows the forest's annual cost per acre and the total annual cost of the various items of expense. Taxes in this county amount to $0.08 per acre; the average cost of fire protection is $0.05 per acre. Possibly this forest can

TABLE 17. -- *Man-days, wages, stumpage values, and other costs of producing lumber, fuelwood, and fence posts on a community forest in Jasper County, Georgia*

Operation	Products	Amount	Man-days required	Value of labor	Other costs	Stumpage value
			Number	----------	*Dollars*	----------
Logging and manufacturing	Pine lumber	707,330 *bd. ft.*	2,122	4,244	4,244	1,768[1]
	Hdwd. lumber	352,210 *bd. ft.*	1,057	2,114	2,113	704[2]
Improvement cutting and cutting of tops	Fuelwood	706 *cords*	612	1,224	188	0
	Fence posts	5,200 *pieces*	90	180	28	0
Thinning	Fuelwood	221 *cords*	191	382	60	0
	Fence posts	2,210 *pieces*	38	76	12	0
Totals			4,110	8,220	6,645	2,472

[1] Pine stumpage at $2.50 per thousand board feet.

[2] Hardwood stumpage at $2.00 per thousand board feet.

be organized with other land into a protection unit under the administration of the State Forester; if so, the community forest would be charged only half of this protection cost. The inventory and marking would cover only that part of the forest to be cut over, 1734 acres, and would include only those trees over 13 inches (d.b.h.). The cost would average about $0.20 per acre. General administration of the forest, which would be a part of that of the whole subsistence homestead, amounts to $0.02 per acre. The planting of one-tenth of the idle land, 133 acres, for each of 10 years would cost about $5.00 per acre, including cost of seedlings and wages. The total annual cost is $2,512, or approximately $0.25 per acre. This cost closely approximates the value of the stumpage cut, which is $2,472, based upon the current stumpage values of pine and hardwood at $2.50 and $2.00 per thousand board feet respectively. Five hundred and forty man-days of labor would be provided by the different cost items during the year: Fire protection, 200; inventory and marking, 100; administration, 40; and planting, 200.

As shown in the preceding paragraphs, the incomes and costs during the first few years on the community forest will show neither profit nor loss. Although there will be no surplus representing interest on the value of the forest investment, an annual total of 4,650 man-days of labor will be furnished; 1,060,000 board feet of lumber, 927 cords of fuelwood, and 7,410 fence posts will be produced and sold at cost to subsistence homesteaders for their home use. Meanwhile the forest will have been put in better growing condition, so that a future yield of greater volume, higher quality, and more valuable products can be expected. Unquestionably, the annual yield of stumpage from this forest can be increased at least three, probably four or more times in volume, and still more in value.

In addition to the money values of the forest's products, its value in preventing soil from washing away is considerable. Other important forest possibilities include the propagation of fish and game as an item of food for the homesteaders, the grazing of live stock and dairy cattle, and recreation.

TABLE 18. -- *Annual costs on a community forest in Jasper County, Georgia*

Item	Acres covered	Man-days required	Cost	
			Per acre	Total
		Number	*Dollars*	
Taxes	10,000		.08	800.00
Fire protection	10,000	200	.05	500.00
Inventory and marking	1,734	100	.20	347.00
Administration	10,000	40	.02	200.00
Planting	133	200	5.00	665.00
		540		2,512.00

USE OF FORESTS FOR SOIL PROTECTION, GAME MANAGEMENT, RECREATION, AND GRAZING

Use of Forests for Soil Protection

The actual returns from a forest are more than the yields in wood products. Soil protection and soil reconstruction, fish and game production, recreation, and grazing of live stock are some of the other uses of a forest from which either direct or indirect returns are received.

Among the most important uses of the forests in the Lower Piedmont Region are the protection of soil against erosion and the reconstruction of soil that has been badly washed by sheet and gully erosion. Since such a large part of the abandoned land has been eroded and so much of it has reverted to forests, a study was made of the effects of forests in checking erosion. Records of active and arrested erosion were taken on 924 one-quarter acre forest plots in old field pine stands and on 512 forests plots in natural forest stands other than old field. About 4 percent of all forest plots showed active or unarrested erosion. In the old field pine forests of the six sample areas, 5.3 percent of the plots showed active erosion as compared to only 1.4 percent of the plots in the other types. The investigation showed, as was expected, that active erosion is found mostly in the young timber and in the poorly stocked stands. Undoubtedly, these young stands will in time arrest the active erosion. Some plots that showed active erosion lay just below large fields that drained through the forest plot, the drainage resulting in active gullying. Fire, which burns off the pine needles and other vegetative cover, frequently opens the area to sheet erosion.

Forest plots with arrested erosion were classified in the following four groups, depending on the degree of erosion which, though arrested, was still apparent: Sheet #1 - no apparent erosion, or mild sheet erosion with less than 30 percent of the B soil horizon exposed; sheet #2 - serious sheet erosion with more than 30 percent of the B soil horizon exposed; gully #1 - occasional gullies; gully #2 - heavily gullied area unfit for agriculture. In old field pine, 94.7 percent of the forest plots showed arrested erosion, divided as follows among the four grades of erosion: Sheet #1, 40.3 percent; sheet #2, 16.5 percent; gully #1, 29.0 percent; and gully #2, 8.9 percent. In other than old field forests, 98.6 percent of the forest plots showed arrested erosion, divided as follows: Sheet #1, 87.3 percent; sheet #2, 2.5 percent; gully #1, 7.8 percent; and gully #2, 1.0 percent. Table 19 shows these erosion conditions by classes of stands for the six sample areas as a whole; table 20 shows erosion conditions for each of the six sample units. On areas with arrested erosion, the trees and other vegetation are gradually rebuilding a fertile layer of top-soil upon the impoverished soils they reclaim.

An interesting contrast of soils was found in Jasper County near Monticello. A natural forest that never had been cleared had a layer of top soil, or A horizon soil, about 12 inches deep. At the edge of the forest the A horizon disappeared abruptly with the beginning of the adjoining cultivated field where sheet erosion was active.

With an Abney hand level, the slope was ascertained for almost all plots on the line plot survey. The forest plots were then classified into the following slope-percent classes: 0-3 percent, 3 to 7 percent, 7 to 12 percent, and over 12 percent. Table 21 shows the relationship between the degree of slope and class of erosion and the class of stand. Slope data for the old field pine type, taken on 918 plots, are distributed as follows: 10.8 percent of the areas had slopes of 3 percent or less;

43.2 percent had slopes between 3 and 7 percent; 30.6 percent had slopes between 7 and 12 percent; and 15.4 percent had slopes over 12 percent. Ordinarily, as shown in the old field pine plots in the different slope classifications, the steeper the degree of slope, the greater the erosion has been in the past. Eighty percent of the old field pine plots having the steepest slopes (12 percent and over) showed evidence of serious sheet or gully erosion in the past, whereas only 3 percent of the plots on gentle slopes showed signs of serious erosion now arrested.

TABLE 19. -- *Percent of forest plots with active and arrested erosion by classes of forest stands for the six sample areas as a whole*

Class of stand	Active erosion	Erosion arrested				Total	Number of plots
		Sheet #1[1]	Sheet #2	Gully #1	Gully #2		
		Percent of total					
Old field pine type:							
Sawtimber well stocked	1.3	39.6	14.3	31.2	13.6	100	154
Young well stocked	5.9	46.1	20.4	21.7	5.9	100	152
Sawtimber medium stocked	2.0	29.8	17.2	36.4	14.6	100	198
Young medium stocked	11.3	44.4	15.0	25.6	3.7	100	133
Sawtimber poorly stocked	1.7	39.0	18.6	33.9	6.8	100	118
Young poorly stocked	10.0	45.6	14.2	24.3	5.9	100	169
Averages and total	5.3	40.3	16.5	29.0	8.9	100	924
Pine hardwood type:							
Sawtimber	1.9	89.8	.9	7.4		100	108
Young	2.1	81.1	2.1	14.7	1.0	100	95
Upland pine type:							
Sawtimber		78.6	7.1	10.7	3.6	100	84
Young	2.7	83.5	3.7	9.2	.9	100	109
Bottomland hardwood pine type:		100.0				100	116
Averages and total	1.4	87.3	2.5	7.8	1.0	100	512

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[1] Sheet No.1 includes plots with no apparent erosion or with mild sheet erosion.

TABLE 20. -- *Percent of forest plots with active and arrested erosion in each of the six sample areas*

Sample areas	Active erosion	Erosion arrested				Total	Number of plots
		Sheet #1	Sheet #2	Gully #1	Gully #2		
		Percent of total					
Old field pine type:							
Jasper	6.6	44.8	14.8	26.2	7.6	100	183
Monroe	5.5	31.3	23.1	29.1	11.0	100	182
Wilkes A.	4.1	61.0	13.7	15.7	5.5	100	146
Wilkes P.	1.7	48.3	14.6	34.5	.9	100	116
Meriwether	5.1	38.7	7.4	36.9	11.9	100	176
Morgan	8.3	16.5	28.1	32.2	14.9	100	121
Averages and total	5.3	40.3	16.5	29.0	8.9	100	924
Other than old field pine type:							
Jasper	2.5	80.2	2.5	13.6	1.2	100	81
Monroe		89.4	3.2	7.4		100	94
Wilkes A.		87.6	2.5	9.9		100	81
Wilkes P.	2.7	84.9	5.5	6.9		100	73
Meriwether	2.3	92.0		5.7		100	88
Morgan	1.1	88.4	2.1	4.2	4.2	100	95
Averages and total	1.4	87.3	2.5	7.8	1.0	100	512

FISH AND GAME PRODUCTION AND RECREATION

The propagation of fish and game, which does not interfere with other uses of the forest, can be made an important part of the management of forests in the Lower Piedmont Region. Most streams are already fairly well stocked with fish, and the land supports numerous rabbits, squirrels, quail, raccoon and opossum. Fish and game now constitute a part of the food used by the population, and this free food could be considerably increased.

The most important management measures are those designed to protect fish and game through strict observance of fishing and hunting seasons and through the limitation of the catch or kill. People in this region are more interested in fish and game for food than for sport (although the latter is important); hence the propagation of food fish, such as channel-cat, red-horse, drum, and buffalo, should be encouraged in the streams and ponds, along with such game as rabbits, squirrels, quail, and opossum in the forest. The sale of hunting and fishing rights also affords an opportunity of obtaining a cash income from game management; but before this is possible, game fish, such as black bass, and wild game, such as quail, wild turkey, deer, and valuable fur bearing animals, must be stocked. Both food and game fish may be propagated, but in general it may be expedient to allot a separate area for each. The practicability

Table 21. - Erosion conditions in the old field pine type by stand classes and degree of slope for the six sample units considered as a whole
Basis 918 plots

Class of stand	Slope 0-3 percent						Slope 3-7 percent					
	Active erosion	Erosion checked				Total	Active erosion	Erosion checked				Total
		Sheet #1	Sheet #2	Gully #1	Gully #2			Sheet #1	Sheet #2	Gully #1	Gully #2	
	Percent of total											
Old field pine type:												
Sawtimber well stkd.	7.3					7.3		24.5	4.0	11.9	2.0	42.4
Young well stkd.	17.2					17.2	2.0	23.8	11.9	10.6	.7	49.0
Sawtimber med. stkd.	7.7					7.7	.5	17.3	5.6	12.8	1.0	37.2
Young med. stkd.	9.8	.8		.7		11.3	5.2	28.6	8.3	12.8	.7	55.6
Sawtimber poorly stkd.	9.3					9.3	.9	19.5	5.1	11.0	.8	37.3
Young poorly stkd.	11.8	.6				12.4	4.7	23.1	1.8	10.0	.6	40.2
Percent of grand total	10.5	.2		.1		10.8	2.2	22.5	6.0	11.5	1.0	43.2
Percent of individual slope totals	97.0	2.0		1.0		100.0	5.0	52.1	13.9	26.7	2.3	100.0

Class of stand	Slope 7-12 percent						Slope 12 percent and over					
	Active erosion	Erosion checked				Total	Active erosion	Erosion checked				Total
		Sheet #1	Sheet #2	Gully #1	Gully #2			Sheet #1	Sheet #2	Gully #1	Gully #2	
	Percent of total											
Old field pine type:												
Sawtimber well stkd.	.7	6.6	8.6	10.6	5.3	31.8	.7	1.3	2.0	8.6	5.9	18.5
Young well stkd.	2.0	5.3	6.0	10.6	2.6	26.5	1.3		2.7	.7	2.6	7.3
Sawtimber med. stkd		3.6	8.7	16.8	6.1	35.2	1.5	1.5	3.1	6.1	7.7	19.9
Young med. stkd	4.5	5.3	3.0	11.3	.7	24.8	1.5	.7	3.0	.8	2.3	8.3
Sawtimber poorly stkd	.9	7.6	7.6	15.3	2.5	33.9		2.6	5.9	7.6	3.4	19.5
Young poorly stkd.	2.4	[illegible]	7.1	11.2	1.8	30.2	3.0	3.0	4.7	3.0	3.5	17.2
Percent of grand total	1.6	5.[illegible]	7.[illegible]	12.7	3.4	30.6	1.4	1.5	3.5	4.[illegible]	4.5	15.4
Percent of individual slope totals	5.4	19.2	22.8	41.6	11.0	100.0	9.2	9.9	22.7	29.1	29.1	100.0

and profitableness of game management have been demonstrated in southern Georgia and northern Florida, where large tracts have been leased to hunting clubs. On other tracts a fee for hunting is charged. Valuable assistance in game management may be obtained by cooperating with such public agencies as the Georgia State Fish and Game Department, the Georgia Forest Service, the United States Biological Survey, and the United States Bureau of Fisheries.

Except for fishing and hunting, the forests of this region will scarcely be used extensively for recreation. The streams are mostly unsatisfactory for swimming, and the climate is not conducive to summer camping.

GRAZING

Individual farmers use the forests and idle land as a range for a few livestock. Grazing, however, is not a large industry in this region and probably will not be of much importance in the future. As forests claim the idle land, and as stocking becomes heavier under fire protection and forest management, the value of the forest as a range for cattle and other livestock wil lbecome less and less.

◆

SUMMARY

The Lower Piedmont Region of Georgia includes 35 counties located just north of the fall line in the central part of the state. More than four-fifths of the region has been cleared at one time or another, but owing to the inroads of the boll weevil and the destructive methods of cultivation that have resulted in serious erosion of the soil, a large part of the total area has been abandoned from cultivation and has reforested to old field pine. Approximately 56 percent of the area was in woodland in 1930, and 43 percent was in cleared land; but only half the cleared land yielded harvest crops. About 40 percent of the cleared land (17 percent of the total area of the region) was idle, and 70 percent of this idle land (12 percent of the total region) was unfit for agriculture. Slightly more than two-thirds of the forested area was in old field pine stands, about 10 percent was in ridge stands of upland pine and hardwoods, 11 percent was in branch head and second bottom pine and hardwoods, and 11 percent was in bottomland hardwoods. Owing chiefly to the heavy cutting of salable timber by farmers who needed a cash income to supplement their diminished crop incomes, most timber stands are poorly stocked with sawtimber trees. Stands are also commonly understocked as to total number of trees. The quality of timber is accordingly poor, resulting in a small annual increment of sawtimber and low stumpage values. The financial possibilities at present are not very attractive, but with management these forests should yield much better returns as well as a satisfactory profit.

In January 1934, 220 small sawmills in this region were allotted production quotas under the Lumber Code totaling 14,128,000 board feet of lumber and involving 42,384 man-days of employment per month. A concentration yard with a planing mill and small portable mills scattered in the better patches of timber is the common setup for lumbering. "Roofers", which sell for about $20.00 per thousand board feet, are the chief product. About three 8-hour man-days are required to log and mill 1,000 board feet of lumber.

A farm in Meriwether County illustrates the financial possibilities of farm woodlands. It has 230 acres of forested land of the following classes: Old field pine, 160 acres; upland pine and hardwoods, 18 acres; branch head and second bottom pine and hardwoods, 32 acres; bottomland hardwoods, 20 acres. In addition, it has 17 acres of idle land, unsuited to agriculture, which should be planted to forest trees. The per-acre volumes and present annual increment of the well stocked old field pine stands are 3,339 and 237 board feet respectively; those of poorly stocked stands are 1,435 and 97 board feet respectively. The present current per-acre stumpage values of the annual increment in well stocked and poorly stocked stands are $0.59 and $0.24 respectively. The total annual increment of sawtimber on the farm is 22,670 board feet of pine and 5,613 board feet of hardwoods; and the total value of this increment, which is also the allowable cut, is $67.91, or $0.30 per are of forested area. In addition to sawtimber, 22 cords of fuelwood and 154 fence posts can be cut from the tops of felled sawtimber trees and from the trees removed in making improvement cuttings and thinnings. The farmer will need the fence posts and about 12 cords of the fuelwood for use on the farm, but he can sell the other 10 cords for $20.00 cash. The annual costs of forest management for the farm woodland are: $0.14 per acre, or $32.20 for 230 acres, as a cash payment for taxes; 3 man-days' labor in fire protection; 26 man-days in improvement cuttings, thinning, and marking for harvest cutting. The cost per acre of planting the idle land is $2.00 for planting stock and 1½ man-days' labor in planting.

A study of financial possibilities of present stands on a 10,000 acre subsistence homestead community forest--- on which the homesteaders furnish all labor for forestry activities, logging and manufacturing; pay, in addition to their contributed labor, the current stumpage value for the timber utilized; and receive in return the forest products---showed that incomes and expenses would balance. The forest products making up the annual cut are: 707,330 board feet of pine lumber; 352,210 board feet of hardwood lumber; 2,210 pine fence posts; 5,200 hardwood fence posts; 575 cords of pine fuelwood; and 353 cords of hardwood fuelwood. The total value of the stumpage, with pine at $2.50 and hardwood at $2.00 per thousand board feet, is $2,472, or $0.25 per acre. The annual costs of forest management and of producing forest stumpage are: $0.08 per acre, or $800 for taxes; $0.05 per acre, or $500 for fire protection; $665 for planting stock and labor to plant 133 acres; $0.20 per acre, or $347 for inventory and marking the annual cut on 1,734 acres; $0.02 per acre, or $200 for administration; a total of $2,512 or $0.25 per acre. A total of 4,650 man-days of labor will be furnished annually to subsistence homesteaders in management activities and in manufacturing forest products.

The plots taken in this study indicate very little active erosion in the forest, even though much of the forest is old field pine that has reestablished itself upon seriously eroded field. The forest's ability to arrest soil erosion is therefore evident; only 5.3 percent of the old field pine stands and 1.4 percent of the natural forest stands other than old field showed active erosion. It was found also in old field pine stands that 10.8 percent of the areas had slopes less than 3 percent, 43.2 percent had slopes between 3 and 7 percent, 30.6 percent had slopes between 7 and 12 percent, and 15.4 percent had slopes greater than 12 percent. Eighty percent of the old field pine stands with slopes greater than 12 percent showed evidence of serious erosion in the past, whereas only 3 percent of the areas on gentle slopes showed signs of serious erosion.

The possibilities of using the forest for fish and game production, recreation, and grazing are also worthy of consideration.

APPENDIX

TABLE 1. -- *General distribution of land area by major use classes. Lower Piedmont Region, based on 1930 Agriculture census*

County	Total land area	Agricultural land	Urban areas	Forested land
Baldwin	196,480	67,459	2,305	126,716
Butts	129,920	66,307	2,167	61,446
Clarke	72,960	42,700	3,818	26,442
Clayton	90,880	51,570	1,868	37,442
Columbia	224,000	72,821	1,487	149,692
Coweta	283,520	134,651	5,926	142,943
Elbert	231,040	116,136	3,626	111,278
Fayette	149,760	62,825	1,466	85,469
Greene	266,240	96,796	2,850	166,594
Hancock	339,200	107,807	2,694	228,699
Harris	320,640	97,312	1,623	221,705
Hart	167,040	103,909	2,268	60,863
Henry	207,360	117,245	2,683	87,432
Jasper	205,440	98,547	3,016	103,877
Jones	241,280	95,273	1,832	144,175
Lamar	117,760	61,143	844	55,773
Lincoln	186,240	55,719	1,570	128,951
McDuffie	183,680	65,053	1,518	117,109
Meriwether	317,440	164,281	5,233	147,926
Monroe	300,800	94,967	3,116	202,717
Morgan	249,600	99,429	3,303	146,868
Newton	167,680	92,594	4,135	70,951
Oconee	110,080	66,036	1,513	42,531
Oglethorpe	322,560	127,545	2,628	192,387
Pike	151,680	82,554	3,373	65,753
Putnam	231,040	74,099	1,546	155,395
Rockdale	76,160	48,592	1,112	26,456
Spalding	133,760	76,646	3,372	53,742
Talbot	199,680	82,363	2,562	114,755
Taliaferro	135,680	53,799	875	81,006
Troup	278,400	119,842	6,706	151,852
Upson	202,880	83,726	2,567	116,587
Walton	211,840	130,703	3,639	77,498
Wilkes	293,120	113,134	3,129	176,857
Warren	258,560	104,136	1,714	152,710
Total	7,254,400	3,127,719	94,084	4,032,597
Percent of total	100.0	43.1	1.3	55.6

TABLE 2. -- *Height growth and mortality in plantations in the Lower Piedmont Region*

No.	Species	Year planted (Spring)	Average height May 1933	Maximum height May 1933	Area	Estimated survival May 1933	Notes [1]
			Feet	*Feet*	*Acres*	*Percent*	
a	Loblolly pine	1931	4	5	1	90	Eroded old field. Slope over 12%.
b	"	1931	3	4	1	95	Eroded old field.
c	"	1931	2½	4	10	95	Eroded old field. Slope 20%.
d	"	1930	5	7	1	95	Planted with alternate rows of cowpeas.
e	"	1930	4	6	1	98	Eroded abandoned pasture. Slope 7-12%.
f	"	1933	½	1½	3	98	Dry sandy old field. Slope 7-12%.
g	"	1927	19	21	1	95	Planted 6 x 8 feet on fair site.
h	"	1929	8	12	10	95	Poor soil. Gully slope over 12%.
i	"	1929	8	13	1	95	Fair, level site. Spacing 6 x 6 feet.
j	"	1930	7	11	1	95	Fair level site.
k	"	1929	3½	5	3	90	Fair level site.
k (1)	"	1929	4½	9	3		Direct seeding excellent stand caught on fair site. Pine straw added.
k (2)	"	1933					Direct seeding apparently a failure.
l	"	1930	3	5	1	92	Tip moth damage. Planted 3 x 4 feet.
m	"	1928	6	11	3	85	Poor site, crowded spacing, 3 x 4 feet.
n	"	1930	3	8	1	75	Good level site. Spacing 6 x 8 feet. Tip moth damage.
o	"	1931	2½	3	40	80	Poor steep site. Dense vegetation.
a	Slash pine	1931	2½	4	20	95	Poor old field site. Slope over 12%.
b	"	1931	3	4	3	90	Poor dry old field site. Slope over 12%.
c	"	1931	3	4	2	95	Poor, gullied slope.
d	"	1931	2½	3½	10	95	Eroded, clay soil. Slope over 15%, spacing 6 x 8 feet.
e	"	1931	3	4½	20	65	Mountainous site. Rocky and dry. Slope over 12%.
f	"	1931	2½	4	7	72	Dry sandy site. Spacing 6 x 8 feet.
g	"	1931	4	6	8	85	Fair site. Slope 3-7%, spacing 6 x 10 feet.
h	"	1931	2	3	10	50	Poor site. Vegetation dense.

TABLE 2. -- *Height growth and mortality in plantations in the Lower Piedmont Region*--Continued

No.	Species	Year planted (Spring)	Average height May 1933	Maximum height May 1933	Area	Estimated survival May 1933	Notes [1]
			Feet	*Feet*	*Acres*	*Percent*	
a	Longleaf pine	1928	4	8	10	90	Good site, spacing 6 x 8 feet.
b	"	1932	2	3½	10	90	Good site. Slope 5%. Spacing 7 x 7.
c	"	1931	1	2	7	85	Poor, eroded site. Spacing 8 x 8.
d	"	1929	3	6	10	70	Poor mountainous site. Slope 10%.
e	"	1931	1	2	1	50	Fair site.
f	"	1931	½	1	100	25	Poor, badly eroded site. Dense vegetation.
a	(Red cedar	1932	3	4	1	90	Old eroded field. Slope over 12%.
	(Black locust	1932	3	4		90	
b	(Tulip poplar	1932	1½	3	1	75	Fair site. Vegetation dense.
	(Loblolly	1931	4	5		90	
c	(Slash	1931	2½	3½	1	95	Eroded hillside old field.
	(Loblolly	1931	2½	3½		95	
d	(Slash	1931	2½	4	10	95	Old field eroded slope. Vegetation dense.
	(Loblolly	1931	2½	4			
e	Black locust	1923	27	40 [2]	1	98	Crowded in planting 6 x 6. Fair site. Damaged by vines.
f	Black locust	1931	7	13	3	90	Poor mountainous site.

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[1] All except two of the plantations were established by planting seedlings; the exceptions were direct seedlings.

[2] The maximum diameter 4-1/2 feet above ground is 6 inches and some of the trees are large enough to yield 3 or 4 small fence posts of excellent quality.

OCCASIONAL PAPER NO. 53
(Reissue, June 30, 1941)

NOVEMBER 20, 1935

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E. L. Demmon, Director

New Orleans, La.

USE OF LAND FOR FORESTS IN THE LOWER PIEDMONT REGION OF GEORGIA

By

W. E. Bond, Forest Economist
and
A. R. Spillers, Associate Forest Economist

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FOREWORD

The study reported in this paper was made under an agreement signed August 15, 1933, between the Regents of the University System of Georgia and the following branches of the United States Department of Agriculture: The Bureau of Agricultural Economics, the Southern Forest Experiment Station, and the Bureau of Chemistry and Soils. When the Division of Program Planning of the Agricultural Adjustment Administration was organized in 1933, the Land Policy Section of that Division continued the cooperation of the Bureau of Agricultural Economics.

The study was made in the Lower Piedmont Region of Georgia. Its primary purpose, as stated in the Memorandum of Agreement, was:

"To determine, for the territory covered, the elements of a land utilization program, based upon a thorough study of physical conditions, present methods of utilization, and economic and social factors which tend to determine present and prospective utilization, and which should be taken into consideration in determining the adjustments requisite in a sound program of land utilization."

This report is the part contributed by the Southern Forest Experiment Station to the project. Portions of this report were published by the Georgia Agricultural Experiment Station as Chapter VI in Bulletin No. 191, "Georgia Land Use Problems." Because the edition of that bulletin was limited, the present report is being published in full in order to reach all those who are primarily interested in the forests.

E. L. DEMMON
Director

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USE OF LAND FOR FORESTS

IN THE LOWER PIEDMONT REGION OF GEORGIA

By W. E. Bond, Forest Economist
and
A. R. Spillers, Associate Forest Economist[1]

THE REGION

Location and Description

The Lower Piedmont Region of Georgia includes about 35 counties located in the central part of the State (see fig. 1). This area of about 7,254,400 acres is bounded on the east and west by the state lines of South Carolina and Alabama, and on the south by the Fall Line, extending approximately from Augusta through Macon to Columbus and forming a topographic demarcation between the Piedmont or foothills and the Coastal Plain. In the north the Lower Piedmont Region may be separated arbitrarily from the Upper Piedmont Region by a line that extends from Hartwell to Carrollton, passing just south of Atlanta. The Lower Piedmont Region extends into Alabama, South Carolina, and North Carolina. Much of the information given in this report will apply to the region in those states as well as to Georgia.

On the whole, the Lower Piedmont is a gently rolling area, adequately drained by some streams that flow southward into the Gulf of Mexico and by others that flow southeastward into the Atlantic Ocean. Its soils, represented chiefly by the Cecil and Davidson series, are derived from ancient igneous and metamorphic formations. The average annual rainfall is about 45 or 50 inches, and the mean annual temperature for the region is between 60 and 65 degrees. An average growing season of about 8 months is conducive to the production of both agricultural and forest crops.

The Lower Piedmont Region is often described as the "old plantations section" because for many years individual land holdings have been so large that usually each owner has employed some tenants or croppers to farm his land. This system of farming still prevails today. Cotton, the principal crop and source of income, has been largely instrumental in forming the present social and economic system in this region. The population in 1930, 53 percent of which was white, numbered 495,196, or 43.6 persons per square mile. Most of these people have always been farmers, but within the last decade the textile industry has developed in the area and has encouraged an increase in population in some of the small towns. The term "old abandoned plantation section" would more accurately describe this region, for abandoned fields are ubiquitous. Old abandoned fields are now reforested to such an extent that 55.6 percent of the total area may be classed as forest area; yet more than two-thirds of the timberland has been cultivated at one time or another.

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[1] The authors wish to acknowledge their indebtedness to all who have aided in any way in the accomplishment of this project, particularly to:
Dr. W. A. Hartman and H. H. Wooten of the Land Policy Section, Division of Program Planning, Agricultural Adjustment Administration, who have planned and carried out the Land Utilization Project as a whole and have furnished the land-use areas and tax data for this report; State Forester B. M. Lufburrow, who assigned an assistant for field work; W. G. Wallace, District Forester, Georgia Forest Service; Prof. G. L. Fuller of the University of Georgia; Mr. Hasty of the Bureau of Chemistry and Soils; A. D. Read, representing the Southern Forest Experiment Station; and W. P. David, representing the Bureau of Agricultural Economics and the Southern Forest Experiment Station.

History of the Region

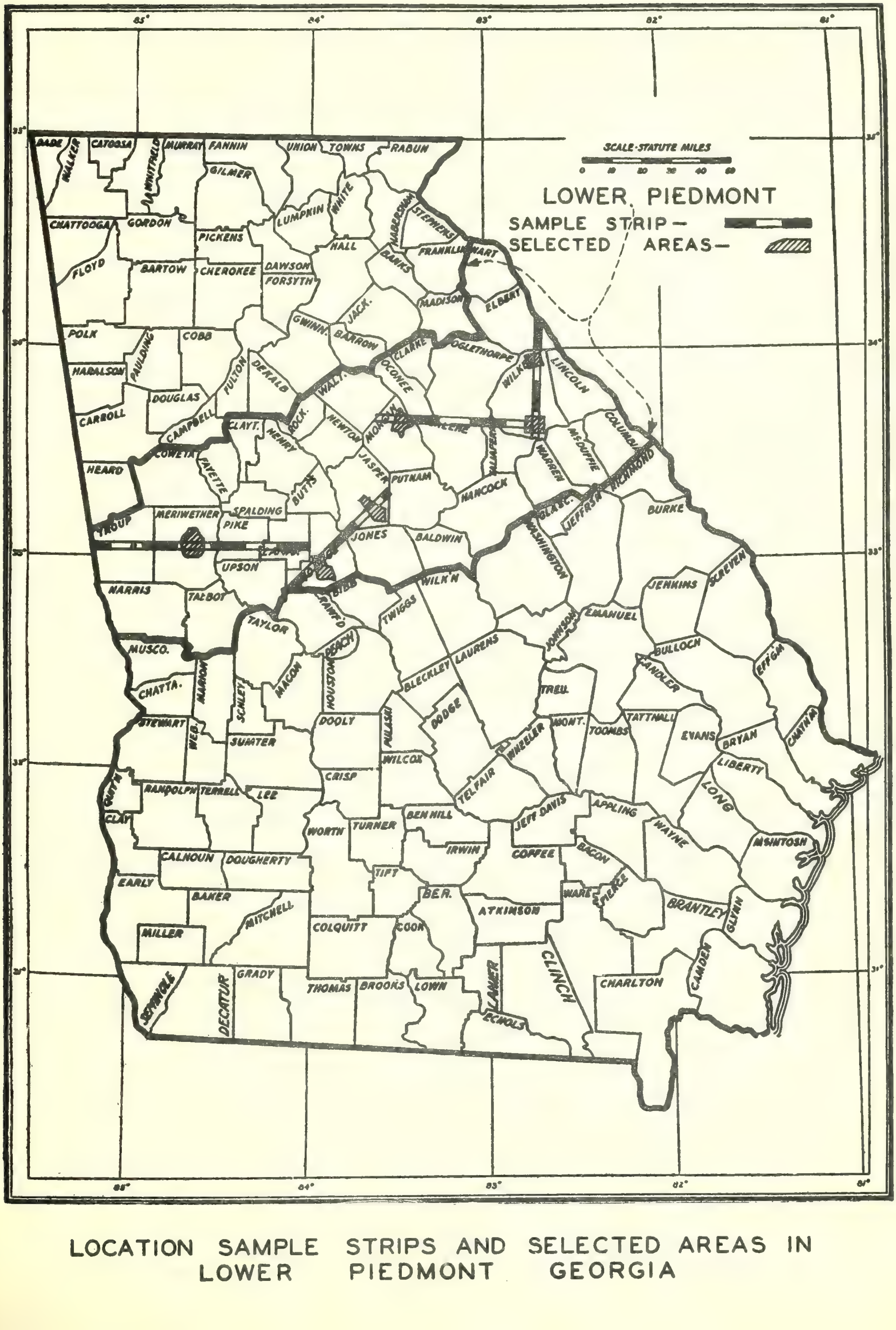
The Lower Piedmont Region of Georgia was settled during the last quarter of the eighteenth and the first quarter of the nineteenth centuries by immigrants from the older settlements of Georgia, Virginia, and the Carolinas. Prior to 1800 the region west of the Oconee River was Indian territory, and settlement was limited to areas east of that river. Early in the nineteenth century the settlers made treaties with the Indians and the land was opened to those from Georgia by lottery, but it was also sold to immigrants who flocked in from Virginia and the Carolinas. The land was soon afterwards dotted by small farms. The first settlers cleared the rich lands on the rivers and creeks, and raised livestock, corn, and wheat. They also cleared, to some extent, the pine uplands. Cotton and tobacco were of little importance until trade received a great impetus after the war of 1812. At first the farms were held by relatively poor men with very few slaves; but as soon as an excellent market for cotton developed, the wealthy planters began to buy up the best land in large blocks and the small owners moved farther west.

Before the Civil War the Lower Piedmont Region of Georgia had become a cotton empire rivaling the coast states. A decade or two after this conflict, the region, having slowly recovered from its economic setback, again became a large factor in the production of cotton. From that time until about 1920 it remained a relatively prosperous region. Since early times, however, the wealth of the country has been concentrated in the hands of a few people. The landowning class of pre-war days had profited from the labors of the slaves and poor whites, with the resulting contrast in standards of living exemplified by the palatial planter's home and the slave shacks or "quarters." During the Reconstruction and afterward, this social condition remained unaltered, for the landowning class built the big homes, usually in the small towns, and rented the land to tenants and sharecroppers.

With little supervision from their town-dwelling landlords, these tenants and sharecroppers have never been careful to adopt conservative measures of cultivation. It matters little to them that the cotton plant exacts much from the soil and gives no protection from erosion during almost half the year; therefore, until recently, soil cover crops and terraces were practically unknown. Old residents in the section recall days when furrows were plowed at right angles to the contours "so each furrow could drain itself," or when a mark was placed at one end of the field so that a plowman, in making his first furrow, headed directly toward his mark regardless of the topography. The light sandy soils of this region eroded so easily that many of the fields, within a few years after having been cleared, became unfit for agriculture and had to be abandoned. But land was plentiful and could be had for the cost of clearing the forest; when one field was abandoned, another area was cleared.

The boll weevil began its wholesale destruction of cotton in 1920, and until checked several years later, this pest continued to devastate entire crops. The crop loss in 1922 was so nearly complete that the financial struc-

FIGURE - I



LOCATION SAMPLE STRIPS AND SELECTED AREAS IN LOWER PIEDMONT GEORGIA ture of the whole region, which was directly connected with agriculture, was severely damaged. During the subsequent years of agricultural depression leading up to the present, recovery has been slow. Compared to erosion, however, which has rendered the land physically unfit for farming, the boll weevil has been but a minor factor in weakening the economic structure of the region.

When the land was first cleared for agriculture, trees were cut and burned. Old residents recall the "log rollings" of early days—social events, when farmers would gather at a given plantation and help to clear the land. Months prior to the "log-rolling" the timber had been girdled so that it would be dry. Fine, big old shortleaf and loblolly pines, oaks, yellow poplars, and other hardwoods were cut, rolled together, and burned. Much of the forest area was thus cleared and only a minute fraction of the vast quantities of virgin timber was utilized for local construction.

More than four-fifths of the Lower Piedmont Region has been cleared at one time or another, but much of this cleared land has been abandoned. The great scarcity of labor following the Civil War resulted in the abandonment of much cropland; and again between 1919 and 1932, owing to the combined agency of erosion and post-war decline in the cotton market, crop acreage decreased about 42 percent.

A large percentage of this abandoned cropland has seeded-in to pine, so that today the old-field pine timber makes up a large part of the total forest area, as well as a large part of the total area of the region. With very few exceptions this region has never known large sawmills. Small sawmills came here about 1913 from the Carolinas and began to cut boards. They obtained their stumpage partly from the small remnant of old-growth timber, but mainly from the old-field stands. Following the severe losses from the boll-weevil invasion, the farmers found relief in the sale of timber.

At first the small sawmill operators paid very little for stumpage, but the World War boom encouraged high prices for lumber and resulted in increased stumpage prices. The small sawmill industry developed rapidly after the war; the peak of lumber production in this region was reached about 1924. By 1929 lumber manufacturing had already shrunk far below that of the peak year, and today (1935) it is at a low ebb. This condition is due not only to the present depression of the lumber market, but also to the rapid diminution of the timber supply. The forest often saved the cotton planter from bankruptcy; but when he sold his timber he considered only his immediate gain—and as a result the forest has been left in a poor condition.

Present Land Use

According to the 1930 Census, only 22.5 percent of the total land area in the Lower Piedmont Region of Georgia is "harvested" cropland; but about 43 percent of the Region is classed as agricultural, which includes crop, pasture, and idle land. Forested land occupies 55.6 percent of the area and urban districts make up the remainder.[1]

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[1] See table 1 in the Appendix for acreages by counties.

Large plantations farmed by sharecroppers and tenants are still characteristic of this region, where about half of the cropland produces cotton. Cover and soil-improvement crops are used on some of these plantations, and contour plowing and terracing are slowly increasing in popularity; but much of the land is still being farmed in such a destructive manner that serious erosion is everywhere apparent. Here, where 40 percent of the cleared land is idle, erosion is the chief agent in the widespread abandonment of land. The fourfold cycle of (1) woodland clearing, (2) farming without erosion control, (3) abandonment, and (4) subsequent reforestation is as common today as in earlier eras, but most of the clearing done now is in woodland that was once field; hence the rate of abandonment is greater than that of clearing.

Fortunately, however, abandoned land does not remain idle very long in most parts of this region. If a cultivated field adjacent to pine seed trees is abandoned, young growth will soon reclaim the land. Given ordinary protection from fire, especially in the early stages of their growth, these young stands usually develop into forests. Over two-thirds of the present forests, occupying about 37 percent of the total area of the Lower Piedmont, are of old-field origin; whereas natural forest land that has never been cleared makes up only about 18 percent of the area.

FOREST CONDITIONS

Types

Two methods of field procedure were followed in studying forest conditions of the Lower Piedmont Region. The first plan involved an intensive investigation in six sample areas, each about 16 square miles in extent, which were chosen as representative of the predominating soils. The forest on the sample areas was mapped according to type, size of trees, density, and merchantability; at the same time the soil, slope, erosion, and other characteristics of the land were also mapped. Forest classifications comparable to those mapped were sampled by taking 1/4-acre plots every 1/16 mile on parallel lines spaced 1/2 mile apart. Two sample areas were located in Wilkes County and one in each of the following: Jasper, Meriwether, Morgan, and Monroe Counties. The second field method involved the mapping of the forest types, tree sizes, density, and other data on a strip running across Georgia through the Lower Piedmont Region. This strip was one-eighth of a mile wide and 208 miles long; it was run generally in a westward direction (see fig. 1).

These field studies have shown that the old-field pine type occupies about two-thirds of the forested area in the Lower Piedmont Region of Georgia. Wherever shortleaf and loblolly pine seed trees grow near an open area, they quickly restock it after abandonment. Loblolly pine is usually slightly more abundant than shortleaf. Hardwoods too, such as red gum, dogwood, elm, maple, and oak, are sometimes found in the old-field type, but they are subordinate components of the stands. In cut-over stands, however, hardwoods become more numerous. The old-field type occurs most commonly on slopes of average steepness that lie between the tops of ridges and the more precipitous slopes to streams. Such situations were once cleared, but because of sheet and gully erosion they have since been abandoned.

The upland pine type, which includes only upland forested tracts that have never been cultivated, occupies about 10 percent of the total forest area. Included in this type are stands containing shortleaf and loblolly pines and hardwoods. Shortleaf usually predominates over loblolly in the stands, but the hardwoods may predominate over both. Hardwoods in the upland pine type include oak and hickory, with red gum, yellow poplar, dogwood, and other hardwoods sometimes in evidence. Most of the stands in this type are confined to the dry ridges and steep slopes.

The pine-hardwood type represents about 11 percent of the forested area of the region. This type includes those characteristically fast-growing stands of mixed pine and hardwoods found upon second-bottom and branch-head sites. Loblolly pine is more commonly found here than shortleaf. The hardwoods usually associated with the pines in this type are yellow poplar, red gum, oak, hickory, maple, sassafras, ash, redbud, and elm. Rarely is this type found upon land that has been cultivated, since cultivation of the precipitous slopes of the branch-head sites and of the poorly drained second bottoms was not usually attempted.

About 11 percent of the forest land falls in the bottomland hardwood type, whose stands are composed almost entirely of hardwood trees. This type, as its name implies, is confined to the bottomlands of the rivers and larger creeks. A wide variation in hardwood species is found, including water oaks, gum, ash, willow, elm, maple, and hackberry. In some places this type is found on land that has been cultivated, but generally the sites are too poorly drained for agriculture.

Where the stands have not been cut and are growing upon old fields, the trees are generally even-aged, although they offer a considerable variation in diameter classes. Logged old-field stands tend to become uneven-aged, for the general practice is to disregard the trees that are too small or too poor for sawlogs. Forests growing on land that has never been cultivated are uneven-aged and generally have a wide range of diameters.

Merchantability

After two decades of cutting by small sawmills, which are especially efficient in gleaning small patches of timber, only a small part of the forested area in the Lower Piedmont Region of Georgia still bears good stands of saw timber. The 1/4-acre sample plots were classed as saw timber if they contained a minimum volume per acre of 1,000 board feet (International 1/4-inch kerf rule) in pine trees that measured 9 inches or over in diameter at breast height. Saw-timber stands of this volume are merchantable in the region. This does not mean, however, that all plots so designated can be profitably harvested, since most of the saw-timber stands are small in area and widely scattered. About half the plots in each forest type that included pine contained 1,000 board feet or more. Table 1 shows the distribution of saw-timber plots by types for each of the six sample areas. Much of the saw timber that has a sale value at present is in small scattered patches where logging is difficult and comparatively expensive even for small sawmills. No attempt is made to give an estimate of the total volume of timber in this region, since the available data are not sufficient to make an accurate estimate.

Density

For old-field pine stands, which represent the major part of the forested area, an additional classification was made on the basis of the density of stocking. Stands were classified into three density classes: Well stocked (at least 50 percent of full stocking), medium stocked (25 to 50 percent of full stocking), and poorly stocked (less than 25 percent of full stocking). Table 1 shows the distribution of 1/4-acre plots by the three degrees of density for old-field stands in the six sample areas. The plots were almost equally divided among the three density classes. Large-sized areas of well-stocked stands are not common in the Lower Piedmont Region, where the forests generally are understocked.

The outstanding reasons that the forests in this region are poorly stocked are the inadequate number of seed trees and the prevalence of fire. Many of the abandoned fields are too remote from forested areas with seed trees, but even in the natural forest area, stocking is generally low because most of the trees of seed-producing size have been logged. Much of the reproduction is killed by fire. According to the 1/4-acre plot samples, about 14.8 percent of the forest area was burned over in 1932. Fires are usually due to the negligence of brush-burners, hunters, or campers, although occasionally an incendiary may deliberately fire the woods.

Erosion, too, plays its part in preventing adequate stocking. Wherever abandoned lands have eroded so badly that their fertile topsoil has been washed away and gullies have been formed, even the pines may find it difficult to establish naturally a forest of adequate stocking. The moist, sandy gully bottoms are ideal seedbeds for pine, but erosion there may be so active that the pine cannot become established. Steep gully banks are difficult sites for reforestation; but wherever erosion is not too rapid and pine seed trees are located nearby, the eroded areas may be naturally reforested. New stands of this type, however, may be somewhat uneven-aged, for the better sites will be seeded first, whereas the poorer sites may not be reforested until the first trees of the new stand, together with other vegetation, have further checked the erosion.

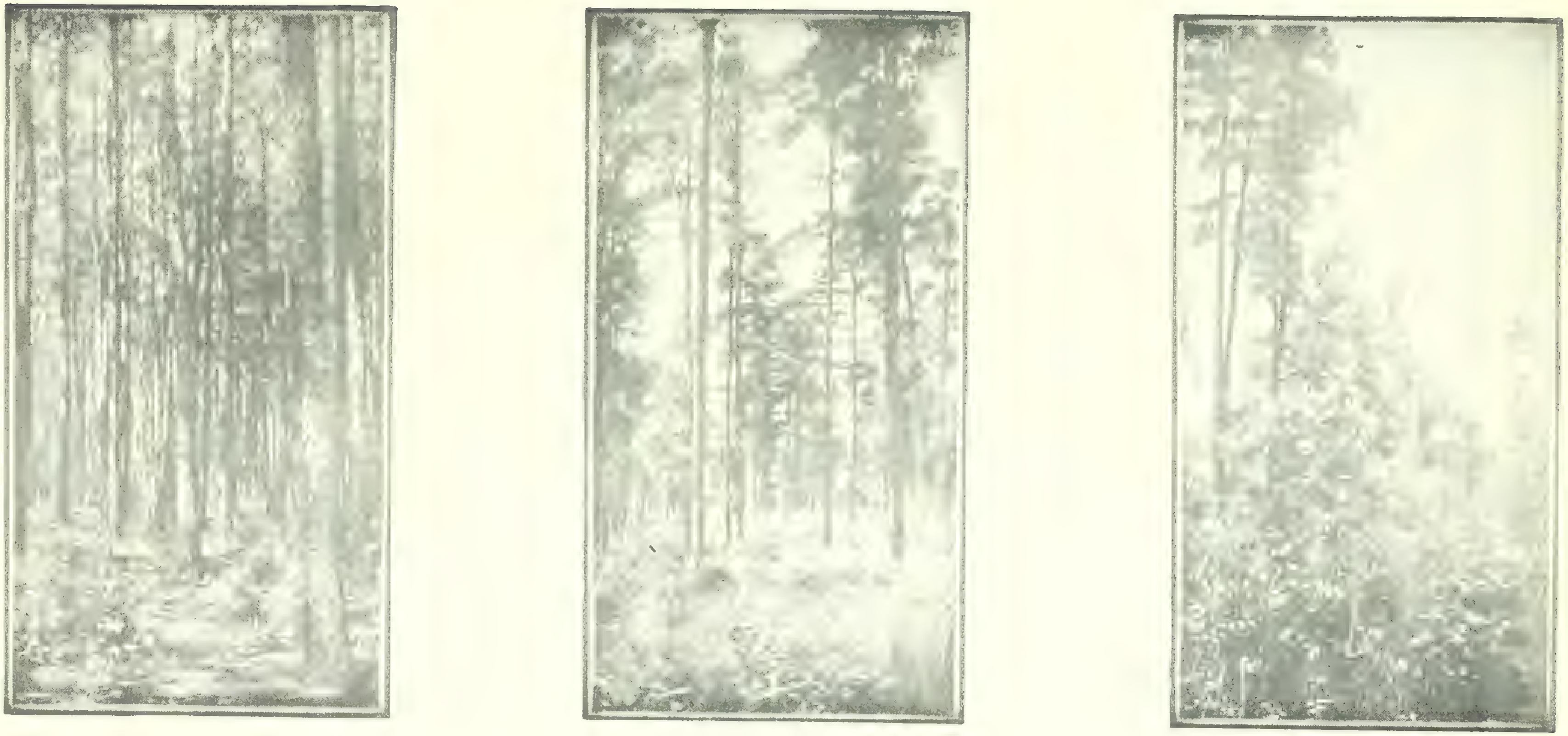
Additional Areas Available for Forests

Other areas, in addition to the land classed as actual forest, will be available for forest growth if the better lands alone are to be used for agricultural purposes. These will include the land now lying idle and generally abandoned because of serious erosion, steep slope, or infertile soil. Forty percent of the open land in both the sample areas and the strip across the State was found to be idle, and about 70 percent of this idle land was classified as unfit for either agriculture or pasture—that is, it was suitable only for forests. Since 43 percent of the Lower Piedmont Region is cleared land, and 40 percent of the cleared land is idle, about 17 percent of the entire region is idle. If 70 percent of the idle land is suitable only for forests, then about 12 percent of the total area of the region is idle land that should be added to the present forest area (55.6 percent of the regional area) to make a total of about 68 percent of the Lower Piedmont Region in present or potential forests. In the above discussion it is assumed that all of the land now being cultivated, as well as the idle land that is suitable for cultivation or pasturage, will continue in that category. The present Federal program of removing submarginal land from agriculture, however, may increase still further the 68 percent of forest area in the region.

Table 1.—Plot distribution in forest stand classes by types in six sample areas[1]

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average percent
	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	Plots	Per-cent	
Old-field pine type:													
Saw timber, well stkd.	27	14.7	18	9.9	19	12.9	28	24.1	45	25.6	17	14.1	16.9
Young, well stkd.	33	17.9	20	11.0	14	9.5	22	19.0	31	17.6	32	26.4	16.9
Saw timber, med. stkd.	33	17.9	36	19.8	39	26.6	21	18.1	38	21.6	31	25.6	21.6
Young, med. stkd.	35	19.0	32	17.6	19	12.9	14	12.1	22	12.5	12	9.9	14.0
Saw timber, poorly stkd.	22	12.0	25	13.7	27	18.4	16	13.8	14	7.9	15	12.4	13.0
Young, poorly stkd.	34	18.5	51	28.0	29	19.7	15	12.9	26	14.8	14	11.6	17.6
	184	100.0	182	100.0	147	100.0	116	100.0	176	100.0	121	100.0	100.0
Other than old-field pine:													
Saw-timber pine & hdwd.	15	53.6	8	17.8	19	55.9	12	42.9	31	75.6	23	79.3	54.2
Young pine & hdwd.	13	46.4	37	82.2	15	44.1	16	57.1	10	24.4	6	20.7	45.8
	28	100.0	45	100.0	34	100.0	28	100.0	41	100.0	29	100.0	100.0
Saw-timber upl. pine	10	41.7	10	31.2	22	55.0	8	26.7	11	37.9	24	68.6	43.5
Young upl. pine	14	58.3	22	68.8	18	45.0	22	73.3	18	62.1	11	31.4	56.5
	24	100.0	32	100.0	40	100.0	30	100.0	29	100.0	35	100.0	100.0
Bottom-land hdwd.	29	100.0	17	100.0	7	100.0	16	100.0	19	100.0	32	100.0	100.0
Forest-land total	265		276		228		190		265		217		

[1] Total number of plots: 1,441 (located in 5 counties).



Well stocked

Medium stocked

Poorly stocked

Figure 2.—Old-field pine stands

Volumes and Growth

Stand tables, volumes, and annual growth in volume in each of the six sample areas were computed for each class of stand in each forest type. Volume in rough cords was figured for the pine trees in the diameter classes 2, 4, 6, and 8 inches, and the averages of the six sample areas show about 6 cords per acre in well-stocked, 2.5 cords in medium-stocked, and 1 cord in poorly stocked old-field pine stands. Details for all stands are given in table 2. Volumes and volume growth for the large trees were computed differently. Since pine trees over 9 inches d.b.h. represent the sizes commonly utilized for lumber, their volumes were computed in board feet by the International 1/4-inch kerf rule because this rule approximates the volume that can be cut out at the mill.

Table 2.—Volumes per acre, in cords, for pine trees under 9 inches d.b.h. in six sample areas

Class of stand	Jasper	Monroe	Wilkes A.	Wilkes P.	Meriwether	Morgan	Average volume
Old-field pine:							
Saw timber, well stkd.	4.25	5.93	5.04	7.23	5.80	6.06	5.72
Young, well stkd.	4.75	6.80	3.08	7.69	6.33	5.82	5.74
Saw timber, med. stkd.	2.25	2.46	2.68	2.56	2.15	2.60	2.46
Young, med. stkd.	2.11	3.23	2.89	2.40	2.43	2.81	2.64
Saw timber, poorly stkd.	.68	.90	1.28	.95	.40	.98	.86
Young, poorly stkd.	1.42	1.15	1.40	.44	1.48	.89	1.13
Other than old-field pine:							
Saw-timber pine & hdwd.	1.21	0.00	.67	1.48	1.24	.87	.91
Young pine & hdwd.	1.31	.50	.20	.78	.96	.49	.71
Saw-timber upl. pine	1.53	2.20	1.71	2.31	4.56	1.74	2.34
Young upl. pine	.14	.44	1.14	1.42	2.18	1.08	1.07

The importance of good stocking of the forest is forcibly brought out by the volumes and increments of three old-field pine stands of different densities, which are averages for the six sample areas. These volumes and increments are as follows: Well-stocked, 5,179 board feet volume, 493 board feet increment; medium-stocked, 3,606 board feet volume, 338 board feet increment; and poorly stocked, 1,989 board feet volume, 164 board feet increment. Details for each stand class are given in table 3.

Numerous mill-scale studies have shown that pine trees below 13 inches d.b.h. are commonly cut at a financial sacrifice; hence in considering saw-timber volumes and increment for the region, this report includes only the trees over 13 inches. Volumes and increments by classes of stands were therefore computed on this basis; for the old-field stands cited above they are as follows: Well-stocked, 2,670 board feet volume, 265 board feet increment; medium-stocked, 1,763 board feet volume, 261 board feet increment; poorly stocked, 964 board feet volume, 143 board feet increment. Details of all stands are shown in table 4.

Hardwoods are not a factor in old-field stands. In the pine-hardwood stands along branches in the six sample areas, the average volumes of hardwoods and pines in trees over 13 inches d.b.h. are 1,717 and 2,364 board feet respectively; the increments, 86 and 94 respectively. Detailed volumes and volume growth for hardwoods are given in table 5. In order to show the distribution of both pines and hardwoods by diameter classes, stand tables for the various stand classes in the Jasper County sample area, taken as an example of the six sample areas, are given in tables 6 and 7. These tables show that most of the trees are below saw-timber size.

Table 3.—Pine volumes and growth[1] per acre for pine trees over 9 inches d.b.h. in six sample areas

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average	
	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth
	Board feet[2]													
Old-field pine type:														
Saw timber, well stkd.	4,735	421	4,651	397	7,178	377	6,102	591	5,391	505	3,016	668	5,179	493
Young, well stkd.	94	239	197	163	113	9	229	207	259	316	94	191	164	188
Saw timber, med. stkd.	3,797	339	3,302	295	3,378	341	3,959	449	3,226	302	3,974	305	3,606	338
Young, med. stkd.	116	134	154	160	227	206	110	72	187	181	0	103	132	143
Saw timber, poorly stkd.	2,030	185	1,882	156	1,952	219	2,031	94	2,252	112	1,788	219	1,989	164
Young, poorly stkd.	117	183	209	108	241	112	230	39	186	121	182	50	194	102
Other than old-field pine types:														
Saw-timber pine & hdwd.	2,546	127	2,784	43	2,735	45	3,832	95	3,053	141	2,301	123	2,875	96
Young pine & hdwd.	631	63	208	24	278	7	333	72	476	49	306	43	372	43
Saw-timber upl. pine	3,209	64	3,029	128	3,860	178	3,188	140	4,095	397	3,514	185	3,482	182
Young upl. pine	85	3	163	23	291	63	251	37	143	45	346	72	213	40

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[1] Annual growth takes into consideration the increase in volume of saw-timber trees, the increase due to trees growing into the minimum saw-timber diameter class, and the trees lost annually due to mortality.

[2] International 1/4" kerf rule.

Table 4.—Volumes and growth1/ per acre for pine trees over 13 inches d.b.h. in six sample areas

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average	
	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth
	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	Board feet2/	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
Old-field pine type:														
Saw timber, well stkd.	2,852	203	2,189	218	3,987	254	2,529	432	3,339	237	1,123	245	2,670	265
Young, well stkd.	16	5	34	4		4		22	35	15	33	8	20	10
Saw timber, med. stkd.	2,186	243	1,724	252	1,623	226	1,591	377	1,780	185	1,676	281	1,763	261
Young, med. stkd.	30	6		16	57	5	69	9		17			26	9
Saw timber, poorly stkd.	939	198	901	158	759	153	1,175	59	1,435	97	574	191	964	143
Young, poorly stkd.	16	7	28	17	43	19	37	25	41	10	114	13	46	15
Other than old-field pine type:														
Saw-timber pine & hdwd.	1,805	122	2,497	69	2,287	77	3,450	96	2,274	139	1,872	61	2,364	94
Young pine & hdwd.	454	38	92	12	200	13	129	30	284	29	176	14	222	23
Saw-timber upl. pine	2,584	83	2,185	94	2,474	165	1,625	188	3,167	120	2,303	181	2,390	138
Young upl. pine		14	71	13		26	99	13	35	4	114	16	53	14

1/ Annual growth takes into consideration the increase in volume of saw-timber trees, the increase due to trees growing into the minimum saw-timber diameter class, and the trees lost annually due to mortality.

2/ International 1/4" kerf rule.

Table 5.—Volumes and growth[1] per acre for hardwood trees over 13 inches d.b.h. in six sample areas

Class of stand	Jasper		Monroe		Wilkes A.		Wilkes P.		Meriwether		Morgan		Average	
	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth	Volume	Annual growth
	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	Board feet[2]	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
Saw-timber pine & hdwd.	1917	96	1577	79	2200	110	1455	73	2106	105	1045	52	1717	86
Young pine & hdwd.	1396	70	3692	185	1997	100	2461	123	2901	145	5019	251	2911	146
Saw-timber upl. pine	2343	117	868	43	1103	55	910	46	778	39	326	16	1055	53
Young upl. pine	3194	160	1736	87	1308	65	848	42	1199	60	300	15	1431	72
Bottom-land hdwd.	3236	162	2017	101	2544	127	756	38	996	50	1536	77	1848	92

[1] Annual growth takes into consideration the increase in volume of saw-timber trees, the increase due to trees growing into the minimum saw-timber diameter class, and the trees lost annually due to mortality.

[2] International 1/4" kerf rule.

Table 6.—Stand table for the old-field pine type in the Jasper County sample area

Diameter[1] class (inches)	Saw timber, well stocked		Young, well stocked		Saw timber, medium stocked		Young, medium stocked		Saw timber, poorly stocked		Young, poorly stocked	
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	Number of trees per acre											
2	202.22	37.04	348.48	9.09	53.33	36.36	151.43	34.86	27.27	36.36	50.59	30.00
4	77.78	15.56	184.85	4.85	29.69	24.85	75.43	8.57	5.46	9.09	27.06	9.41
6	55.56	1.48	106.66	2.42	27.88	8.48	41.71	7.43	10.00	7.27	20.58	3.53
8	28.89		19.39		18.18	.61	10.86	1.71	6.37	7.27	14.71	
10	17.03	.44	1.09	.36	11.52	.48	1.26	.11	8.18	1.45	1.53	.47
12	10.96	.44	.24	.24	11.15	.48	.23	.23	7.27	.55	.24	.59
14	6.07	.59	.12	.24	4.49	.97	.22		2.91	.36	.12	.24
16	3.26			.12	3.51	.36			1.09	.36		.35
18	2.66	.15			1.94	.73			.91	.36		.12
20	2.22				1.45	.24			.18			
22 & up	1.04				.48				.36			
Total	407.69	55.70	660.83	17.32	163.62	73.56	281.14	52.91	70.00	63.07	114.83	44.71

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[1] At 4.5 feet from ground.

Table 7.—Stand table for three forest types in the Jasper County sample area

Diameter[1] class (inches)	Pine-hardwood type				Upland pine type				Bottomland hdwd. type; all classes of hdwds.
	Saw timber		Young		Saw timber		Young		
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	
	Number of trees per acre								
2	24.00	118.67	16.92	109.23	32.00	76.00	11.43	62.86	132.42
4	17.33	57.34	15.39	53.84	14.00	32.00	12.86	37.15	83.45
6	21.33	33.33	18.46	36.93	22.00	26.00		31.49	50.36
8	5.33	17.34	6.16	24.62	6.00	10.00			21.38
10	5.87	6.40	1.23	4.62	2.00	4.00		5.15	5.94
12	4.80	3.20	1.23	7.99	5.20	5.60	.86	4.01	5.38
14	4.54	4.00	1.54	3.39	2.00	2.40		2.01	2.49
16	2.67	3.21	.62	2.78	1.20	2.40		1.44	3.45
18	1.33	2.40	.62	1.24	1.20	2.40		2.30	2.63
20	1.06	1.06		.93	2.00	1.20		2.00	1.68
22 & up	.53	.27		.62	1.60	3.20		4.87	2.10
Total	88.79	247.22	62.17	246.19	89.20	165.20	25.15	153.28	311.28

[1] At 4.5 feet from ground.

A few of the 1,441 sample plots taken on the strip survey show excellent volume and yield, although nothing has been done consciously to assist this growth. Twenty of these natural stands of optimum condition and productivity may give some idea of the maximum yields that can be expected. Possibly these stands, which were found on only a minute portion of the area, were growing upon only the very best sites; but since they are natural stands, it may well be possible to grow forests somewhat comparable to them if careful forest management is practiced upon average sites. The best 1/4-acre plot had a volume of 47,704 board feet per acre at 77 years from seed, and the average of the 20 optimum plots had 20,382 board feet per acre in trees over 13 inches d.b.h. at 65 years. Unless the general poor quality of the material is considered, however, all saw-timber volume and growth figures for this region may be misleading. Excessively limby trees and other trees of poor quality are included in these figures because they are utilized in this region for boards, the principal product. Only a very small percent of the stumpage will produce better than No. 2 Common boards of the Southern Pine Association specifications.

All increments take into consideration the increase in volume of saw-timber trees, the increase due to trees growing into the minimum saw-timber diameter class, and the trees lost annually through mortality. The annual mortality of pine in each forest type by diameter classes, as found from a tally of dead trees on the 1/4-acre plots, is given in table 8. It is generally 1 or 2 percent of the total number of trees per acre. The rate of diameter growth of pine in all stand classes is quite rapid, but is especially so for old-field pines up to about the 14-inch diameter class, where, probably because of density, it falls off rapidly. The rate of diameter increase is also less in the better-stocked stands. A 10-inch old-field pine, for example, increases in diameter during a 5-year period as follows: In well-stocked stands, 2.05 inches; in medium-stocked, 2.20 inches; and in poorly stocked, 2.50 inches. Diameter growth by diameter classes and by classes of stands is given in table 9.

The effect of erosion upon the growth of forests is difficult to measure. When forests reclaim eroded land, a long period of time elapses before the impoverished soil is enriched with organic material. This period is affected greatly by fire. The forest growth is further retarded until the soil is built up to a condition of fertility and good composition. Density and the many factors of site, however, are so influential in the rate of growth that it is difficult to establish the effect of erosion alone upon forest growth.

Table 8.—Annual mortality of pine in six sample areas

Diameter[1] class (inches)	Old-field pine type	Pine-hardwood type	Upland pine type
	Percent		
2	1.2	0.5	0.6
4	1.5	1.4	1.8
6	1.8	2.2	2.2
8	1.8	2.5	2.2
10	1.7	2.4	2.2
12	1.6	2.4	2.2
14	1.4	2.3	2.2
16	1.2	2.2	2.2
18	1.1	2.2	2.2
20	1.0	2.2	2.2
22	.9	2.2	2.2
24	.9	2.1	2.2
26	.9	2.1	2.2
28	.9	2.1	2.2
30		2.0	2.2

[1] At 4.5 feet from ground.

Table 9.—Diameter growth (wood and bark) of pines in a 5-year period, Jasper County sample area, in inches, at breast height

Diameter class (inches)	Old-field loblolly pine			Old-field shortleaf pine		
	Well stocked	Medium stocked	Poorly stocked	Well stocked	Medium stocked	Poorly stocked
2	2.55	2.80	2.80	1.50	1.65	2.00
4	2.75	2.90	3.00	1.55	1.65	2.00
6	2.70	2.70	2.90	1.40	1.65	1.85
8	2.45	2.45	2.80	1.30	1.50	1.70
10	2.05	2.20	2.50	.95	1.30	1.40
12	1.65	1.75	2.20	.75	.95	1.05
14	1.30	1.40	1.85	.65	.85	.95
16	.85	1.10	1.65	.40	.75	.75
18	.55	.85	1.40	.40	.60	.75
20	.45	.75	1.40	.40	.60	.70

Diameter class (inches)	Pine-hardwood type		Upland pine type	
	Loblolly pine	Shortleaf pine	Loblolly pine	Shortleaf pine
2	1.85	1.00	1.55	1.00
4	1.90	1.00	1.50	1.00
6	1.90	1.00	1.50	.95
8	1.90	1.00	1.45	.95
10	1.90	1.00	1.45	.95
12	1.90	1.00	1.45	.90
14	1.90	1.00	1.45	.90
16	1.90	.95	1.40	.90
18	1.85	.95	1.40	.90
20	1.75	.95	1.40	.90
22	1.65	.95	1.40	.90

FOREST INDUSTRIES

Lumbering

Small mills have sawn nearly all the timber that has ever been cut in the Lower Piedmont Region of Georgia. Since the beginning of the World War, when many of these small sawmills began cutting, the principal product has been pine boards or "roofers," although small quantities of pine and hardwood dimension have also been cut, chiefly for local consumption. "Roofers," a trade name given to the pine boards, generally infers total mill run, which is mainly No. 2 Common pine boards.

The usual lumbering set-up in this region consists of a planing mill and concentration yard, located in a town upon a main-line railroad; and several small sawmills in the woods, which cut and deliver the rough lumber to the planer. The sawmills, or "peckerwoods" as they are commonly called, are easily moved about to cut scattered tracts of timber. Both steam- and tractor-powered outfits are found. Their cut in an average day's run is from 3,000 to 10,000 feet board measure. At a steam sawmill (slightly larger than the average), cutting 7,000 feet board measure per day, eight men did the logging; eight others, the sawing; and three men, employed half time, hauled the rough lumber 14 miles to the concentration yard. Approximately one-third of a man-day was required at the planer per thousand feet planed and loaded on cars. A total of about two and a half 10-hour man-days, or about three 8-hour days were required to produce 1,000 feet of "roofers."

The industry was active in 1929, and common wages in the sawmill were about $1.25 to $1.50 per day for common laborers, and $3.00 to $4.00 for the sawyer. "Roofers" sold for about $17.50 per thousand board feet. Second-growth pine stumpage sold for $2.50 to $3.50 per thousand board feet; virgin timber, for $5.00.

Sawmills in this section were operating less in 1932 than in any other year since the World War. "Roofers" sold at this time for an average price of about $7.50 per thousand board feet, loaded in cars; wages at the sawmills were generally 50¢ to 60¢ per 10-hour day for common labor and $1.50 for the sawyers. (At this time many farm laborers received from $5.00 to $7.00 per month, without board.) Pine stumpage, on the basis of mill tally, sold for $1.00 to $2.00 per thousand board feet. At the operation previously outlined, the planing mill or concentration yard bought the timber stumpage for $1.00 per thousand board feet lumber tally; it paid $3.50 per thousand to a contractor for logging and sawing, and $1.50 per thousand for hauling the rough lumber to the planer. Total cost to the planer was $6.00, leaving $1.50 for planing, loading, and selling. This work provided jobs, but very low wages and very little profit.

As a result of the lumber industry's having adopted the Code of Fair Competition in 1933, common wages are 24¢ per hour, and No. 2 Common boards have a minimum price of about $20.00 per thousand board feet at the mill. Pine stumpage is about $2.50 per thousand board feet. Since the Code became effective, wages have been raised 380 percent above the low levels existing in 1932 and the first half of 1933. Because wages and salaries account for about 44 percent of the total manufactured value of lumber and timber products for the entire southern pine industry,[1] a commensurate rise in the price of lumber was expected.

In January 1934, 220 sawmills in the Lower Piedmont Region of Georgia were allotted production quotas under the Lumber Code. The total allotment amounted to 14,128,000 board feet. Allowing three man-days for logging and manufacturing 1,000 board feet of lumber, the cutting of this allotment would have furnished 42,384 man-days of employment per month. If the allotment had been cut at a minimum wage of $1.92 per 8-hour day (a certain percentage of the men, however, would have been employed as skilled laborers at more than minimum wages), the wages paid out would have totaled about $85,000 per month.

Fuel-Wood Production

Farmers sold large quantities of fuel wood in 1932 for consumption by small industries and homes. Although soft coal was cheap, many of the cotton gins, cottonseed mills, ice plants, and other industries used wood (the local product) to help the farmers whose usual incomes were greatly depressed. One cottonseed mill manager stated that 10 cords of wood or 6 tons of bituminous coal were required to generate power sufficient for crushing 20 tons of cottonseed. With cordwood selling for $2.25 per cord and coal for $3.50 per ton, the cost of milling with wood as fuel was only about 7½¢ greater per ton of cottonseed. About 6 bales of cotton may be ginned per cord of wood.

Cordwood in 4-foot lengths sold in 1932 for $1.50 to $2.50 per cord, or an average price of $2.00 delivered in town. This price allowed 50¢ per cord for cutting, $1.25 for hauling, and 25¢ for stumpage. Fireplace wood in 1½- and 2-foot lengths sold for about $3.00; stovewood in 14-inch lengths sold for about $4.00 per cord. Approximately 1.5 man-days are required for cutting a cord of stovewood, while 1 man-day is needed for fireplace wood. An average of 12 cords of wood is used annually on the farms for heating and cooking purposes. A few posts and sawlogs also are cut occasionally for farm home needs.

Other Wood-using Industires

Only small quantities of wood are used for purposes other than lumber or fuel. A mill at Monticello, Ga., manufactures bobbins and shuttles, but the raw material is shipped in from other regions. Beech, birch, and hard maple are used for bobbins, and dogwood and persimmon for shuttles. In 1929 this plant employed 45 people full time at an average wage of $2.00 per day, but in 1932 it operated only two-thirds of the time with 25 people, each of whom received about $1.25 per day.

A small volume of white and red oak stumpage in trees of merchantable size occurs in scattered tracts, usually along the branches. If this timber is sound and is 18 inches or larger in diameter, it is suitable for staves for tight cooperage. In 1932, a limited number of staves, to be used in the manufacture of barrels for beer, wine, and whiskey, were prepared in this region for the export trade. They were hand-rived by a crew of three men, who cut from 200 to 250 staves per day. Although 4 different sizes are made, the bolts, when dry, are usually 4½ inches wide, 2 inches thick, and 4 feet long. White oak staves sold f.o.b. for 10¢ each and red oak staves for 7¢ each; about 40 percent of this price was said to have been paid for stumpage. Great impetus has been given to the production of staves since the repeal of the Eighteenth Amendment, so that prices and wages have risen accordingly. The stumpage volume of high-quality oak, however, is so small that it prevents a widespread development of the oak-stave industry in this region.

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[1] Wackerman, A. E. and Spillers, A. R. "Labor Versus Machinery, etc." Southern Lumberman, 46 (1853): 21-23, June 1933.

The forest resources of the region, if properly managed, could no doubt support additional wood-using industries. These industries would have to depend for some time upon poor-quality second-growth timber, but with forest management the quality and quantity could be greatly improved and increased.

FINANCIAL POSSIBILITIES OF FOREST MANAGEMENT IN PRESENT FOREST STANDS

Present Production of Forests

The preceding chapters have shown that about two-thirds of the total forest area of the Lower Piedmont Region is in old-field pine stands, and that most of these stands are understocked and composed of a poor quality of timber. The same is true of other than old-field stands. This deficiency of good saw timber is due chiefly to the fact that farmers have been forced to strip their forest lands of salable timber when farm crops have failed to yield the necessary cash requirements. The small number of wood-using industries and the small volume of lumber cut in the region at present, as compared to the very active lumber industry during the late 1920's, are the direct effects of this scarcity of saw timber.

Forest management under these circumstances does not promise immediate profits of much consequence. In order to obtain satisfactory profits in forest management, the growing stock in large trees (17 inches and over d.b.h.) must be built up. Moreover, the quality of the timber must be improved by increasing the density of stands. Such improvements can be attained in future stands by protecting the abundant natural reproduction against fire and by limiting the cut to only the largest saw-timber trees and the poor-quality trees. Hardwoods, which come in after cutting, aid materially in naturally pruning the pines and in improving the site.

Estimated Future Yields of Forests Under Management

Since it is impossible to account for the many factors that may influence volume growth, the prediction of future yields of forests under management for longer than 5- or 10-year periods, even though it be based on the most careful measurements of growth and mortality, cannot be accurate. The increment of well-stocked saw-timber stands is a fair indication of what can be expected from the understocked stands after they have been built up under forest management. But even the well-stocked saw-timber stands of this region are at present understocked in the large diameter classes; hence their average yearly increment of 265 board feet per acre in the six sample areas is low. The yearly increment in this class of stand in the Wilkes Pistol sample area was 432 board feet per acre.

The average volume per acre of twenty of the best-stocked mature-timber plots taken on the line-plot survey in the region was 20,383 board feet (International 1/4-inch kerf rule) in trees over 13 inches d.b.h. The average age of these stands was 65 years, but the present annual increment was not determined. Judging by these data, it is not unreasonable to expect average volumes of at least 10,000 board feet per acre in saw-timber trees, and annual increments of at least 500 board feet per acre after the stands have been built up under intensive sustained-yield management. Such an increase in volume will materially improve the quality of the material, and these two factors will in turn greatly increase the value of the yield.

Regulated Cutting

Little thought is given at present to the growing of crops of timber in this region, where the forest has always been exploited. In planning forest management, the owner's immediate financial requirements must be considered; but the conservation of capital values should not be lost sight of. The cut must be limited to the annual growth if a sustained yield or a perpetual income from forest property is desired; and the forest growing stock must be built up to include a proper distribution of tree sizes, so that as the large, old trees are cut, smaller and younger ones grow up to take their places. Most of the stands in this region are made up chiefly of trees below saw-timber size which, if properly managed, will have a much greater annual growth, or increment, in a few years than they have now. The quality of the timber can be improved by cutting out undesirable trees; besides, the land owners need a current cash income. For these reasons, during the next 5 or 10 years it would be desirable to cut the increment of saw timber 13 inches and over d.b.h., but the cut should not exceed this increment.

Numerous studies have shown that large trees not only yield more valuable forest products than small ones, but also that they cost less per unit to log and saw. It is essential that the growing stock of the present forests be built up so that financially mature trees can furnish the current yield and provide for future cuts. Along with harvest cutting of saw-timber trees, stand improvement work should be carried on to improve the growing stock. Trees not suited for future growth, such as rough trees, large overtopping trees, and thinning material, should be removed if their removal will pay for itself.

A selection system of cutting, under which groups of trees as well as single trees are removed, is suitable for both old-field and natural forest stands in this region. Although stands can be cut over annually, it is usually more economical to cut once every 5 or 10 years in order to get a heavier cut per acre. Inventories almost invariably show that stands are better stocked in the small diameter classes than in the saw-timber sizes, and that natural reproduction comes in abundantly. The allowable cut of saw-timber volume depends upon stand increment. In determining this allowable cut, however, only the increment of trees over 13 inches d.b.h. need be considered, since these are the trees that will be removed either in the present cut or in a later one. The annual cut should not exceed the sum of the net current growth of these trees on all parts of an ownership.

In order to determine the annual growth, or increment, of the stand, it is necessary to determine the diameter growth, and then to apply this diameter growth to the trees in the stand. The volume of the present stand subtracted from the volume of the stand after 1 year's growth (in diameter and height) gives the volume growth for 1 year. The farm woodland owner or other woodland owner may require the assistance of the state forester or the state extension foresters in making these calculations. If such assistance is not available, the application of the annual volume growth found and reported in this bulletin for stands similar to those under consideration may be made without serious error. The annual growth of saw timber (trees 13 inches and over d.b.h.) found in this region amounts roughly to 10 percent of the board-foot volume in old-field pine stands and 5 percent in other stands. If the landowner, in determining the allowable cut, applies these percentages to the volume in his stands, and then limits the cut to high-grade saw-timber trees (17 inches and over d.b.h.) and to other trees that should be removed to improve the stand, he will be handling his timber in a manner consistent with good forestry practices.

Large forest properties should be subdivided into permanent management units. The trees should be carefully selected and marked before cutting. Sufficient high-quality large trees should be taken in the first cut to obtain a fair income, but the aim should be to leave the most valuable species and the best-formed trees so that productivity in quantity and quality might be built up and the largest future earnings assured. The present market for stumpage utilizes poor-quality field timber. When marking for sustained yield on large forest properties, a tally should be made of all trees 13 inches and larger d.b.h. that are to be cut, and a separate tally of those trees over 13 inches that are to remain. The first tally will make sure that the marking does not include a volume exceeding the present increment; the second tally will indicate the approximate future increment and cut. The cost of such marking and inventory runs about 5¢ per thousand board feet in fairly well stocked saw-timber stands, or about 20¢ per acre. Between 40 and 60 acres can be covered by a crew of three or four men in an 8-hour day.

Fire Protection

Fire control is one of the first requirements of forest management. The line-plot surveys in the six sample areas showed that 14.8 percent of the forest land burned over in 1932. On small holdings, such as a farm woodland, fire protection may mean nothing more than constant vigilance and the prompt extinction of fire when it does occur. Large properties, however, require a carefully planned detection system of well-placed lookout towers, a well-organized system of fire and telephone lines, and a thoroughly trained detection and suppression force. Intensive protection of large areas has been found to cost about 5¢ per acre per year.

Planting

While natural reproduction can be depended upon where seed trees are now present, certain areas of idle land and cut-over areas lack seed trees and therefore require planting in order to produce a forest. Approximately 40 plantations of forest trees were visited in 1933 in the Lower Piedmont Region of Georgia. The oldest loblolly pine plantation was established in the spring of 1927. After 6½ growing seasons the survival was over 95 percent; the average height, 19 feet; and the maximum height, 21 feet. Some of the trees measured

5 inches or slightly more in diameter at breast height. The oldest slash pine plantations visited were established in 1931. After 2½ growing seasons the average height of the slash pines was 2 to 4 feet; the maximum height, about 6 feet. The oldest black locust plantation was planted in 1923. On a poor site this species had a survival of 98 percent, a maximum height of 40 feet, and a maximum diameter at breast height of 6 inches.

Additional information on plantations may be obtained from the data shown in table 2 in the Appendix. In general, the following conclusions may be drawn:

1. Loblolly and slash pines have been the most favored species for planting; but longleaf pine, black locust, yellow poplar, and red cedar are sometimes used.

2. Plantations are generally established upon old fields, and the area in plantations of individual ownership is usually about 1 to 10 acres; some are 20 acres or larger. The planting sites are often eroded slopes upon which the soil is poor and the drainage excessive.

3. The trees were usually set in February at 6-foot intervals in plowed furrows spaced about 8 feet apart. Spacings 6x6 and 6 x 7 feet were also found.

4. The cost of establishing plantations was extremely low because the stock was usually furnished by the Georgia State College of Forestry at Athens for $1.50 to $2.50 per thousand, and most of the planting work was done by farm labor at $0.50 per day. Total cost was about $2.00 to $3.00 per acre.

5. Survival was good in most of the plantations studied, even though some were upon poor, dry, eroded sites. The greatest survival percentage was often found where the vegetation was sparse and where sheet erosion had removed much of the topsoil. The fastest growth was often found in the bottom of the washes or shallow gullies, probably because greater moisture is available there than upon the slopes. Good survival but relatively poor growth were found in deep gullies and on steep slopes. Seedlings could not survive at all in the few places where erosion was most active, unless grasses and other vegetation helped the trees to arrest it and protected the seedlings from washing out or silting over.

6. Loblolly pine and black locust seem to give the most satisfactory results in planting. Mixed rather than pure plantings of these species are the more satisfactory; for in managing mixed stands, it is possible to harvest the locust for posts after 13 years, thus leaving thinned the remaining stand of pine. Insect pests attack both species: the tip moth, the pine; and the locust borer, the black locust. What little damage they caused in this region, however, was confined to pure, densely planted stands.

7. Although this region is north of the natural range of slash pine, that species may prove excellent for planting purposes. Slash pine plantations established here to date are not yet old enough to prove the feasibility of planting that species; but after two growing seasons it was making excellent growth even upon poor, dry sites. Slash pine, yellow poplar, red cedar, and other species should not be planted in large tracts until the present plantations or subse-

quent small ones are old enough to demonstrate the adaptability of these species to different sites. Although no plantations of shortleaf pine were found (possibly because it is not as favored as some of the more rapidly growing species), this species is adapted to growing upon the poor sites of the region, and its hardiness makes it valuable for erosion control and for lumber or pulpwood production.

Taxes

Taxes must be paid each year whether or not the cleared land or the woodland produces an income. The assessors do not, as a rule, recognize the timber volume present in the stand. According to a study of this region made by the Bureau of Agricultural Economics of the Department of Agriculture, cultivated, idle, and forest land are assessed identically for real estate taxes. The two main factors that govern the evaluation of land are the buildings and other improvements, and the availability of good roads. The rates of assessment and taxes per acre were found to vary somewhat in different counties; they also varied as to the owner's residence and the size of his property. Table 10 shows the assessed value and taxes per acre, as obtained by the Bureau of Agricultural Economics for each of the five counties in which sample units were studied, in relation to residence of owners and to size of holdings, as well as the averages for the five counties.

This study of taxes and ownership in the Piedmont Region shows that 80 percent of the total area of the region is held by owners that reside in the county in which their land lies, or in the county adjacent thereto; that 16 percent is held by owners that reside in the State, but outside the county or adjacent county; and that 6 percent is held by owners that reside outside the State. Land belonging to residents outside the State is usually assessed slightly more than that of residents living on or near their properties. The study also showed the following percentages of total area falling in each size of holding:

Acres	Percent of total area
2 - 49	2.9
50 - 174	25.7
175 - 499	32.9
500 - 999	16.8
1,000 - 1,999	11.4
2,000 & over	10.3

Per-acre assessments for large properties seem to be a little less than those for small ones.

FINANCIAL POSSIBILITIES OF FARM WOODLANDS

Farm woodlands in the Lower Piedmont Region contribute to the cash income from the farm; they also furnish the fuel supply for the home, and the fence posts and other wood products needed for farming. In order to show present forest conditions, increment, and financial possibilities of farm woodlands in the Lower Piedmont Region, a typical farm mapped in the Meriwether sample area has been selected. A study of size of ownership made in 1932 by the Bureau of Agri-

Table 10.—Assessed value and taxes per acre in five counties in the Lower Piedmont Region of Georgia

Classification of owners and holdings	Jasper		Monroe		Wilkes		Meriwether		Morgan		Average	
	Ass'd value	Taxes	Ass'd value	Taxes	Ass'd value	Taxes	Ass'd value	Taxes	Ass'd value	Taxes	Ass'd value	Taxes
	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - Dollars	- - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
Residence of owner:												
County or adjoining county	3.32	0.089	4.68	0.119	4.74	0.123	4.55	0.133	6.64	0.147	4.79	0.122
State but outside of county or adjoining county	2.92	.075	5.04	.128	4.90	.133	4.38	.126	6.72	.149	4.79	.122
Outside of State	3.20	.085	5.08	.128	4.41	.112	5.82	.170	7.61	.169	5.22	.133
Size of property, in acres:												
2 - 49[1]	3.77	.115	60.54	1.532	13.01	.379	6.02	.164	-	-	16.67	.438
50 - 174	2.93	.084	4.72	.119	5.74	.155	5.14	.148	6.55	.155	5.02	.132
175 - 499	3.57	.111	4.49	.114	4.80	.127	4.81	.139	7.16	.164	4.93	.131
500 - 999	3.12	.084	4.92	.125	4.85	.129	4.81	.138	6.84	.150	4.91	.125
1000 - 1999	3.24	.081	4.44	.112	4.70	.117	4.29	.129	6.73	.149	4.68	.118
2000+	3.07	.077	4.16	.105	3.77	.100	4.37	.130	6.19	.136	4.31	.110

[1] Assessments in this class often include especially valuable properties, as exemplified in Monroe county.

cultural Economics, U. S. Department of Agriculture, revealed that the 175 to 499 acre class contained the largest acreage of farm land in this county, as well as in the whole region. The farm selected has a total area of 297 acres, of which 230 are forested and 17 are idle land, suitable for forests but not for agriculture. Cultivated land makes up 37 acres; idle land suitable for agriculture, 13 acres. The forest woodland is made up of the following classes of stands: Saw-timber old-field pine, 88 acres; young old-field pine, 72 acres; pine-hardwood type along the branches, 32 acres; upland pine type on a ridge, 18 acres; and bottomland hardwood along the creek, 20 acres. (For definitions of types and classes of stands, see pages 5 to 7.) The proportion of area in each class approximates that found in the Meriwether sample area closely enough to render the farm a good example of the sample area as a whole. The areas occupied by stands of different densities in old-field stands, and by saw-timber and young stands in the pine types other than old-field, could not be mapped because they are too closely intermingled. These areas on the farm were derived by applying the same proportions of each as those determined by the line-plot survey on the sample unit. Table 11 shows the area of each class of stand in the farm woodland.

The merchantable pines in all types range from 13 inches to about 20 or 22 inches, but the majority are in the lower diameters. Many of these trees are limby and of poor quality, especially in the old-field pine stands. Pines growing with hardwoods in natural forest stands are of much better quality.

Table 11 applies volumes and annual increments found in the Meriwether sample area to the stands in the farm woodlands. This table shows a total annual increment of 22,670 board feet of pine and 5,613 board feet of hardwoods in trees over 13 inches d.b.h. The annual increment in well-stocked old-field pine saw-timber stands is 237 board feet of pine per acre, whereas that of poorly stocked old-field stands is 97 board feet of pine. Saw-timber stands in the pine-hardwood type have an annual volume growth per acre of 139 board feet of pine and 105 board feet of hardwoods; those in the upland pine type, 120 board feet of pine and 39 board feet of hardwood. Bottomland hardwoods, from which most of the merchantable trees have been cut, are annually growing only 50 board feet per acre. These per-acre saw-timber volumes indicate that the growing stock is low. The maximum volume of pine, 3,339 board feet per acre, occurs in well-stocked old-field stands. If properly stocked, this stand would have more than double that volume of saw timber. Virtually all stands need to be built up, especially in the larger diameters.

The total cut in this farm woodland during the next 5 years should not exceed the present annual increment. With the majority of the trees in the small diameter classes, this annual increment would thereby increase during the 5-year period, so that by holding the cut at the present increment the stand itself would increase. Moreover, in cutting this increment, as much of the cut as possible should come from poor-quality trees that are not desirable for future growth. As many high-quality trees as possible should be left for future cuts, but in order to obtain sufficient volume the largest trees of both high and low quality must be taken. One reason for leaving the high-quality trees for a future cut is that owing to the large percentage of present sales volume in low-quality lumber, no price distinction is made in favor of higher-quality products. The price commonly paid for stumpage is about $2.50 for pine and $2.00 for hardwoods, measured in lumber stacked after sawing. The total value of the allowable cut of saw timber, which equals the present increment, is therefore $56.68

Table 11.—Areas, volumes, and annual increment of saw timber over 13 inches d.b.h. in a farm woodland in the Meriwether sample area

Class of stand	Area	Volume				Annual increment			
		Per acre		Total		Per acre		Total	
		Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	Acres	Board feet							
Old-field pine type:									
Saw timber, well stocked	40	3,339	-	133,560	-	237	-	9,480	-
Saw timber, medium stocked	35	1,780	-	62,300	-	185	-	6,475	-
Saw timber, poorly stocked	13	1,435	-	18,655	-	97	-	1,261	-
Young, well stocked	27	35	-	945	-	15	-	405	-
Young, medium stocked	21	-	-	-	-	17	-	357	-
Young, poorly stocked	24	41	-	984	-	10	-	240	-
Pine-hardwood type:									
Saw timber	24	2,274	2,106	54,576	50,544	139	105	3,336	2,520
Young	8	284	2,901	2,272	23,208	29	145	232	1,160
Upland pine type:									
Saw timber	7	3,167	778	22,169	5,446	120	39	840	273
Young	11	35	1,199	385	13,189	4	60	44	660
Bottomland hardwoods	20	-	996	-	19,920	-	50	-	1,000
Totals	230			295,846	112,307			22,670	5,613

for pine stumpage and $11.23 for hardwood stumpage. Table 12 gives the value of the present annual increment of saw timber for each class of stand. This value varies from $0.59 per acre for well-stocked old-field pine saw-timber stands to $0.24 per acre for those that are poorly stocked. The value of the annual increment of saw-timber pine-hardwood stands is $0.35 per acre for pine stumpage and $0.21 for hardwood stumpage, a total of $0.56. In upland pine saw-timber stands, the per-acre value of annual pine increment is $0.30; that of hardwood, $0.08. As volume and quality of timber improve, these values will increase correspondingly. Owners can augment their cash income by doing their own logging and by selling the logs at the roadside or at the sawmill.

Table 12.—Volume and stumpage value of annual increment of saw timber over 13 inches d.b.h. in a farm woodland in the Meriwether sample area

Class of stand	Area	Annual increment per acre				
		Volume		Value		
		Pine	Hardwood	Pine1/	Hardwood2/	Total
	Acres	- - Board feet3/	- - - - -	- - - - Dollars	- - -	- - -
Old-field pine type:						
Saw timber, well stocked	40	237	-	.59	-	.59
Saw timber, med. stocked	35	185	-	.46	-	.46
Saw timber, poorly stocked	13	97	-	.24	-	.24
Young, well stocked	27	15	-	.04	-	.04
Young, med. stocked	21	17	-	.04	-	.04
Young, poorly stocked	24	10	-	.02	-	.02
Pine-hardwood type:						
Saw timber	24	139	105	.35	.21	.56
Young	8	29	145	.07	.29	.36
Upland pine type:						
Saw timber	7	120	39	.30	.08	.38
Young	11	4	60	.01	.12	.13
Bottomland hardwoods	20	-	50	-	.10	.10

1/ Pine stumpage at $2.50 per thousand board feet.
2/ Hardwood stumpage at $2.00 per thousand board feet.
3/ International 1/4-inch kerf rule.

The first cut of saw timber, designed to remove 28,283 board feet of pine and hardwood, should cover one-fifth of the saw-timber areas. Where saw-timber and young stands are intermingled, however, as in the pine-hardwood and upland pine types, it will be necessary to cover one-fifth of the total area of these types. Table 13 gives the areas, volumes, and stumpage values included in this first cut of saw timber. Each cut made annually during the succeeding 4 years will cover an area and remove a volume of wood about equal to those of the first cut, thus completing at the end of 5 years the first cutting cycle, during which all saw-timber stands will have been cut over. During several subsequent cutting cycles, approximately the same volumes will be cut from the same areas; but inasmuch as the stands are meanwhile increasing, especially in trees of saw-timber size and quality, eventually both the volume of the annual cut and the area covered can be enlarged. Volumes of future cuts, made each 5 years in stands that have been grown under management, should, on a per-acre basis, equal at least the 5 years' increment of present well-stocked stands; these volumes will probably amount to between 2,000 and 2,500 board feet per acre.

Table 13 also shows the quantity of fence posts and fuel wood that can be cut from tops of saw-timber trees and from improvement cuttings and thinnings. The volume of fuel wood available from tops of saw-timber trees amounts, approximately, to 1/4 cord of pine and ½ cord of hardwood per 1,000 board feet of pine and hardwood sawlogs respectively; an equal proportion is available from trees removed in stand improvement, thus making a total cut of ½ cord of pine and 1 cord of hardwood to 1,000 board feet of pine and hardwood. Only 27 acres, or 37.5 percent of the entire 72 acres in the young stands of old-field pine, are stocked sufficiently to need a thinning. If one-fifth of the total area in young stands (14.4 acres), is covered the first year, then only 37.5 percent (5.4 acres), is dense enough to thin. In order to liberate crop trees, which will make up future saw-timber cut, about 1 cord of fuel wood and 10 fence posts per acre will be cut as thinnings from the 5.4 acres. From the 4 acres in the bottomland hardwoods that are being cut for saw timber, 25 hardwood fence posts per acre will be cut from low-quality trees. This cut of fuel wood and fence posts can probably be maintained in future cuts. At present there is no market for pulpwood in this region; and because of the low value of fuel wood, the labor cost of producing it virtually equals its present sale value. The owner of this farm will use 12 of the 22 cords of fuel wood cut; he can sell the remaining 10 cords for about $2 per cord delivered. If he hires a wood cutter, he will come out even; but if he cuts and delivers the wood himself, he will receive $20 for his efforts.

The owner of this farm woodland can therefore place it under sustained-yield management without spending any cash over and above his present expenditures. His annual taxes amount to about $0.14 per acre as usual; but his fire protection cost amounts to nothing more than an average of 3 days a year spent in fighting fires that threaten his property. By educating his neighbors concerning fire damage he can even reduce that cost.

Before cutting, the different classes of stands should be subdivided into 5 areas, each of about the same acreage, and boundaries should be blazed out. The cut for the first year would then be limited to 1 area in each class of stands. Subdividing will require of the farmer and his helper about 3 days' time. Three more days' time of 2 men, including two-thirds of a day with a truck, will be required to cut and haul 5.4 cords and 54 fence posts, the thinnings from 5.4 acres scattered over 14.4 acres. These thinnings should remove only the trees

Table 13.—Annual cut of saw timber, fence posts and fuel wood on a farm woodland in the Meriwether sample area

Class of stand	Area cut	Saw timber									Fuel wood		Fence posts	
		Volume				Stumpage value								
		Per acre		Total		Per acre		Total						
		Pine	Hdwd.	Pine	Hdwd.	Pine[1]	Hdwd[2]	Pine	Hdwd.	Total	Pine	Hdwd.	Pine	Hdwd.
	Acres	Board feet[3]				Dollars					Cords		Number	
Old-field pine type:														
Saw timber	17.6	1,035		18,218		2.59		45.55		45.55	9.1			
Young	14.4										5.4		54	
Pine-hardwood	6.4	558	575	3,568	3,680	1.39	1.15	8.92	7.36	16.28	1.8	3.7		
Upland pine	3.6	246	259	884	933	.61	.52	2.21	1.87	4.08	.4	.9		
Bottomland hardwoods	4.0		250		1,000		.50		2.00	2.00		1.0		100
Total	46.0			22,670	5,613			56.68	11.23	67.91	16.7	5.6	54	100

[1] Pine stumpage at $2.50 per thousand board feet.
[2] Hardwood stumpage at $2.00 per thousand board feet.
[3] International 1/4" kerf rule.

that are crowding out the previously selected crop trees, spaced from 10 to 15 feet apart. An additional day's work for 2 men will be required to cut and deliver the 100 hardwood posts from the bottomlands. Two men will need about 2 days to mark the trees for harvest and improvement cuttings, and to take an inventory of saw-timber trees on the 31.6 acres to be covered the first year. Technical help in marking can be obtained by applying to the State and Extension Foresters. The purchaser of the 28,283 board feet of stumpage will require approximately the following men, equipment, and time for logging and hauling: 2 men felling and bucking for 7 days; 1 man and team loading for 7 days; and 1 man and truck hauling for 7 days. The farmer and his helper can then come in after the logging and cut the discarded tops, as well as the trees they intend to fell for improvement cuttings, into fuel wood; this work will require 5 days and will produce 16.9 cords of fuel wood. The 2 men will need 2 more days to deliver 10 cords to town and 6.9 cords to the farm house.

This farm has 17 acres of idle land, unfit for agriculture, which should be planted to loblolly, black locust, and a few miscellaneous species. It is proposed to plant one-fifth of the area, or 3.4 acres, during the first of the 5 years. Seedlings can be purchased from the State at about $2 per thousand. If planted about 6 x 7 feet, or 1,000 to the acre, the area will require 3,400 seedlings at a total cost of $6.80. To plant an acre with this spacing requires about 1.5 man-days, or 5.1 man-days for the 3.4 acres. The farmer can do this work himself. Table 14 shows the detailed possibilities of such a plantation.

The following outline shows the operations, with costs and incomes, which the owner will carry out in putting the farm woodland under sustained-yield management.

1. Subdivision of woodland into 5 areas, one of which is to be cut each year.
   (a) Cost: 3 days' time of 2 men, or 6 man-days. This is not an annual requirement; it is done only once.
   (b) Income: None.

2. Inventory and marking of trees to be cut in the first cutting area of 31.6 acres.
   (a) Cost: 2 days' time of 2 men, or 4 man-days.
   (b) Income: None.

3. Sale of saw-timber stumpage from 31.6 acres.
   (a) Cost: None.
   (b) Income: 22,670 board feet of pine stumpage at $2.50 per thousand board feet; 5,613 board feet of hardwood stumpage at $2.00 per thousand board feet—a total cash income of $67.91.

4. Thinning of young stands on 14.4 acres of old-field pine.
   (a) Cost: 3 days' time of 2 men, or 6 man-days; and use of a truck for two-thirds of a day.
   (b) Income: 5.4 cords of fuel wood used on the farm; 54 pine fence posts.

5. Improvement cuttings and cutting of tops into fuel wood on 31.6 acres.
   (a) Cost: 8 days' time of 2 men, or 16 man-days; and 2.5 days' use of truck.
   (b) Income: 10 cords of wood sold for $20.00 cash; 6.9 cords of wood used at the farm house; and 100 hardwood fence posts used on the farm.

6. Protection against fire of 230 acres of woodland and 17 acres of idle land to be planted to forest trees.

(a) Cost: 3 days' time of 1 man fighting fire, or 3 man-days.
(b) Income: None.

Table 14.—Planting costs and returns per acre

Date	Work	Cost	Stumpage returns
1935 or first year	Plant 1,000 trees 6 x 7 feet in mixtures generally comprising 400 black locust, 400 loblolly, and 200 miscellaneous, including shortleaf, red cedar, and yellow poplar.	Planting labor $1\frac{1}{2}$ man-days; planting stock $2.	
1945 or tenth year	Survival is 80% and trees average 3 inches d.b.h. Thin, leaving 500 trees per acre (200 locust, 200 loblolly pine, 100 miscellaneous).	1 man-day per acre.	
1955 or 20th year	Allowing for mortality and growth there will be 450 trees averaging 6 inches. Thin by removing the 180 remaining locust. 270 trees are left.		180 locust trees or 360 posts.
1965 or 30th year	Allowing for mortality and growth there will be 240 trees averaging 10 inches d.b.h. Cut 140 trees, leaving 100.		140 trees averaging 50 ft. b. m. per tree, or 7,000 at $2.00 per M—$14.00.
1985 or 50th year	Allowing for mortality and growth there will be 90 trees averaging 17 inches d.b.h. Cut 60 trees, leaving 30.		60 trees averaging 270 ft. b. m. per tree, or 16,200 at $4.00 per M—$64.80.
1988 or 53rd year	Cut the remaining 30 trees averaging 18 inches. In last 3 years natural young growth will have become established at no cost.		30 trees averaging 310 ft. b. m. per tree, or 9,300 at $4.00 per M—$37.20.
	Taxes for 53 years at $.14 per acre (without interest)	$7.42	
	Total in 53 years	$9.42	$116.00
	Net income per year (without interest)		2.01

7. Planting of 3.4 acres of idle land annually for 5 years.
   - (a) Cost: 3,400 seedlings at $2.00 per thousand—$6.80; 1.5 man-days per acre, or 5.1 man-days.
   - (b) Income: No income for about 20 years, or until fence posts and fuel wood may be cut.

8. Payment of taxes on 230 acres of woodland and 17 acres of idle land to be planted to forest trees.
   - (a) Cost: $0.14 per acre, a total of $34.58 per year.
   - (b) Income: None.

Since the farmer and his family can do most of the work required to put the farm woodland under management, cash charges for labor need not be set up; on the other hand, since many of the products cut are used on the farm rather than sold, cash values need not be applied to them. The only cash costs are taxes, $34.58, and tree seedlings, $6.80; the cash incomes are stumpage, $67.91, and fuel wood, $20.00. The net cash income for the year considered is $87.91 less $41.38, or $46.53. The cost of gasoline and depreciation against the truck are also to be considered, but the farmer can often deliver his wood when making a necessary trip to town for another purpose.

If those annual activities of the owner that yield no income—such as fire protection (3 man-days valued at $6.00); marking and inventory work (4 man-days valued at $8.00); cutting and hauling the 10 cords of wood (time of men and truck valued at $20.00)—are charged against the income along with taxes and cost of pine seedlings, then the net income is $87.91 less $75.38, or $12.53. It must be remembered, however, that the farm woodland has now been put into condition for more volume and better quality growth. Unquestionably, the annual yield of stumpage from this forest can be increased at least three, probably four or more times in volume, and still more in value. If the farmer does his own logging and transports the logs to the sawmill, he will need 28 man-days of labor, 7 days' use of his team, and 7 days' use of a truck; but he can obtain about $6.00 per thousand board feet for logs delivered at the mill, or a total of $169.70 instead of $67.91, the present stumpage price.

In addition to these tangible values in timber products which the farm woodland provides, it also prevents serious erosion of land, serves as a pasture for livestock and a habitat for wild game, and has important recreational value.

Financial Possibilities of Subsistence Homestead Community Forests

A subsistence homestead project has been proposed for Jasper County, Ga. A community forest has been considered as a part of this undertaking, and it is desirable to know the financial possibilities of such a forest. In order to illustrate these possibilities, a hypothetical 10,000-acre forest has been set up, which has the same proportion of forest types, classes of stands, and idle land suitable only for forests as were found in the Jasper County sample area (8,700 acres). The volumes, annual increment, and other forest data found in this unit have also been adopted. Cultivated land and idle land suitable for agriculture have not been considered for forests, since they will be used for cultivation.

This forest of 10,000 acres is made up of 8,670 acres of forests and 1,330 acres of idle land, which is potential forest land, as it is unsuitable for agriculture. It consists of 5,980 acres of old-field pine; 870 acres of pine and hardwoods that grow along the second bottoms of the larger streams and along branches; 780 acres of pine and hardwoods that grow on the ridges; and 1,040 acres of hardwoods in the bottomlands of the larger streams. The potential forest land consists of abandoned fields and pastures, which are unsuitable for agriculture because of erosion, steepness of slope, or poor soil quality.

The areas, volumes, and annual increment of saw timber of each class of stand within the forest types are shown in table 15. (See pages 5 to 7 for definitions of forest types and classes of stand; stand tables for each class of stand are shown in tables 6 and 7.) The total annual increment of saw timber (trees over 13 inches d.b.h.) in present stands is 707,330 board feet of pine and 352,210 board feet of hardwoods. It so happens that the present annual increments in the three classes of saw-timber stands in the old-field pine type do not vary greatly because the heavier densities of the better-stocked stands are in the small diameters, which do not enter into the saw-timber increment at present. The maximum annual increment in old-field pine is 243 board feet per acre, and the maximum present volume of saw timber is 2,852 board feet. Pine-hardwood saw-timber stands have an annual increment of 122 board feet of pine and 96 board feet of hardwood per acre on a volume of 1,805 board feet of pine and 1,917 board feet of hardwoods. Upland pine saw-timber stands have an annual increment of 83 board feet of pine and 117 board feet of hardwoods per acre, and a volume of 2,584 board feet of pine and 2,343 board feet of hardwoods. Bottom hardwoods are growing 162 board feet on a volume of 3,236 board feet. Almost all stands are understocked in the saw-timber diameter classes, particularly the old-field and open stands, and much of their volume is in poor-quality timber that will saw out no better than No. 2 Common boards.

To obtain an annual income and also to improve the stands so that they will yield a larger volume of higher-quality material, it is desirable to cover the entire forest once each 5 years, making thinnings, improvement cuttings, and harvest cuttings. Approximately one-fifth of the forest should be covered each year, and, in order to distribute the work as evenly as possible over the 5-year period, approximately one-fifth of the area in each stand class should be included, but the area to be cut should be blocked up as nearly as possible into one unit. Before beginning the cut, the areas to be cut should be located on the ground and the trees should be marked for cutting. A map based on aerial pictures that shows forest stand classes for the entire county will be available within a year; it will be of great assistance in planning and locating the cut on the property.

The total annual cut of saw timber on one-fifth of the forest should not exceed the total present annual increment of saw timber on the whole property. Since much of the growing stock is below saw-timber size, a large part of which is approaching saw-timber size, it is permissible to cut this present annual increment. Along with the logging, a considerable volume of fuel wood can be cut from tops of saw-timber trees and from trees cut in stand improvement. For every 1,000 board feet of pine logs cut on this property, about 1/4 cord of fuel wood can be cut from tops and another 1/4 cord from trees cut in stand improvement. Twice these amounts can be cut, namely, 1 cord of fuel wood, per 1,000 board feet of hardwood logs. On every 4 acres of bottomland hardwoods, about 100 fence posts can be obtained in addition to the fuel wood. Fence posts can be cut

Table 15.—Areas, volumes, and annual increment of sawtimber over 13 inches d.b.h. in a community forest in Jasper County, Ga.

Class of stand	Area	Volume				Annual increment			
		Per acre		Total		Per acre		Total	
		Pine	Hardwood	Pine	Hardwood	Pine	Hardwood	Pine	Hardwood
	Acres	- - - - - - - - Board feet - - - - - - - -							
Old-field pine type:									
Saw timber, well stocked	880	2,852	-	2,509,760	-	203	-	178,640	-
Saw timber, medium stocked	1,070	2,186	-	2,339,020	-	243	-	260,010	-
Saw timber, poorly stocked	720	939	-	676,080	-	198	-	142,560	-
Young, well stocked	1,070	16	-	17,120	-	5	-	5,350	-
Young, medium stocked	1,140	30	-	34,200	-	6	-	6,840	-
Young, poorly stocked	1,100	16	-	17,600	-	7	-	7,700	-
								601,100	
Pine hardwood type:									
Saw timber	470	1,805	1,917	848,350	900,990	122	96	57,340	45,120
Young	400	454	1,396	181,600	558,400	38	70	15,200	28,000
								72,540	73,120
Upland pine type:									
Saw timber	330	2,584	2,343	852,720	773,190	83	117	27,390	38,610
Young	450		3,196		1,438,200	14	160	6,300	72,000
								33,690	110,610
Bottomland hardwoods	1,040	-	3,236	-	3,365,440	-	162	-	168,480
Total forested	8,670			7,476,450	7,036,220			707,330	352,210
Potential forest land now idle	1,330								
Total	10,000								

also in thinning young stands of old-field pine, but only 1 acre out of every 3 is dense enough to need thinning. On those areas with dense stands it is estimated that 1 cord of fuel wood and 10 pine fence posts per acre will be cut in thinning. Table 16 shows the areas, volumes, and stumpage values included in the first cut of saw timber by forest types; the number of fence posts and cords of fuel wood that will be cut from tops and in improvement cuttings; the areas of young stands in old-field pine to be thinned; and the number of fence posts and cords of fuel wood to be cut.

The total annual cut of saw timber, which is also the present saw-timber increment, is 707,330 board feet of pine and 352,210 board feet of hardwoods. Since the present value of stumpage per thousand board feet is $2.50 for pine and $2.00 for hardwoods, the total value of pine stumpage is $1,768; that of hardwood stumpage, $704. But because one of the purposes of the subsistence homestead is to provide employment, it is not likely that this stumpage will be sold; probably it will be logged and manufactured into lumber by subsistence homesteaders, and possibly used by them in building homes, barns, and other necessary buildings. About 3 man-days of labor are required to produce 1,000 board feet of lumber; hence a total of 3,179 man-days would be required to cut the total volume. If the minimum Lumber Code wage of about $2.00 per day is paid, $6.00 per thousand board feet of lumber, or a total of $6,358 worth of labor, will have been provided. Wages make up about 50 percent of the total lumbering costs; if a sum approximately equal to the cost of labor is added for trucks, teams, depreciation of plants, and other overhead costs, the cost of the lumber before adding stumpage costs is $12.00 per thousand, or $12,715 total. The addition of the present current stumpage value of $2,472 brings the total cost of the lumber to $15,187, which is approximately $14.33 per thousand board feet.

Subsistence homestead farmers will also cut 706 cords of fuel wood and 5,200 fence posts from tops and from trees removed in improvement cuttings. Two men can cut approximately 3 cords of fuel wood or 150 fence posts per day, and 2 men with a truck can haul about 10 cords of fuel wood or 500 fence posts per day from the woods to the farm houses. To cut 706 cords of fuel wood, 471 man-days of labor are necessary; to cut 5,200 fence posts, 69 additional man-days are required. The hauling of fuel wood and fence posts combined consumes 162 man-days, 141 for the fuel wood and 21 for the posts. The total man-days of labor necessary for cutting and hauling amount to 702; at $2.00 per day, they represent $1,404 in wages.

The cutting and hauling of 221 cords of fuel wood and 2,210 pine fence posts removed in thinning 662 acres requires 229 man-days, 191 for the fuel wood and 38 for the posts; at $2.00 per day, this labor is valued at $458. To cut and haul a cord of fuel wood costs about $2.00 - $1.33 labor cutting, $0.40 labor hauling, and $0.27 cost of the truck; the same cost for 100 fence posts is $4.00, or $2.67 labor cutting, $0.80 labor hauling, and $0.53 cost of the truck. For cutting and hauling fuel wood and fence posts in this community forest, the farmers will probably be reimbursed with fuel wood and fence posts at the cost price rate of $2.00 per cord for fuel wood and $4.00 per 100 fence posts.

Man-days required to cut lumber, fence posts, and fuel wood in harvest, improvement, and thinning cuttings during the first year total 4,110; the value of this labor is $8,220. Table 17 shows the distribution of labor in man-days, value of labor, other costs, stumpage values, and amount of forest products cut by operations. Although the lumber could probably be sold for an average price

Table 16.—Annual cut of saw timber, fence posts, and fuel wood on a community forest in Jasper County, Ga.

Class of stand	Area cut	Sawtimber									Fuel wood		Fence posts	
		Volume				Stumpage value								
		Per acre		Total		Per acre		Total						
		Pine	Hdwd.	Pine	Hdwd.	Pine[1]	Hdwd.[2]	Pine	Hdwd.	Total	Pine	Hdwd.	Pine	Hdwd.
	Acres	- - - - Board feet[3] - - -				- - - - - - - - - - Dollars - - - - - - - -					- Cords -		- Number -	
Old-field pine saw timber	534	1,126	-	601,100	-	2.82	-	1,502.75	-	1,502.75	301	-	-	-
Old-field pine, young	662	-	-	-	-	-	-	-	-	-	221	-	2,210	-
Pine-hardwood saw timber and young	174	417	420	72,540	73,120	1.04	.84	181.35	146.24	327.59	36	73	-	-
Upland pine saw timber and young	156	216	709	33,690	110,610	.54	1.42	84.22	221.22	305.44	17	111	-	-
Bottomland hardwoods	208	-	810	-	168,480	-	1.62	-	336.96	336.96	-	168	-	5,200
Total	1,734			707,330	352,210			1,768.32	704.42	2,472.74	575	352	2,210	5,200

[1] Pine stumpage at $2.50 per thousand board feet.
[2] Hardwood stumpage at $2.00 per thousand board feet.
[3] International 1/4" kerf rule.

of $18.00 or $20.00 per thousand board feet, it would doubtless be good policy to sell it to the homesteaders at cost, $14.33 per thousand board feet, allowing credit for such labor as they contribute. The other forest products could be sold on the open market for about the cost of production, but they will probably be exchanged for labor contributed. The only net income from the forest with which to meet taxes, administrative costs, and other expenses is the stumpage value of the saw timber cut—$2,472. Spreading this over 10,000 acres gives an annual income of about $0.25 per acre per year.

Table 17.—Man-days, wages, stumpage values, and other costs of producing lumber, fuel wood, and fence posts on a community forest in Jasper County, Ga.

Operation	Products	Amount	Man-days required	Value of labor	Other costs	Stumpage value
			Number	- - - -	Dollars	- - - -
Logging and manufacturing	Pine lumber	707,330 bd. ft.	2,122	4,244	4,244	1,768[1]
	Hdwd. lumber	352,210 bd. ft.	1,057	2,114	2,113	704[2]
Improvement cutting and cutting of tops	Fuel wood	706 cords	612	1,224	188	0
	Fence posts	5,200 pieces	90	180	28	0
Thinning	Fuel wood	221 cords	191	382	60	0
	Fence posts	2,210 pieces	38	76	12	0
Totals			4,110	8,220	6,645	2,472

[1] Pine stumpage at $2.50 per thousand board feet.
[2] Hardwood stumpage at $2.00 per thousand board feet.

The annual costs on this community forest are for taxes, fire protection, inventory and marking, administration, and planting. No costs for roads or other improvements are included because it is understood that the county and State will bear costs of roads, and that workers on the forest will be housed on their subsistence homestead farms. Table 18 shows the forest's annual cost per acre and the total annual cost of the various items of expense. Taxes in this county amount to $0.08 per acre; the average cost of fire protection is $0.05 per acre. Possibly this forest can be organized with other land into a protection unit under the administration of the State Forester; if so, the community forest would be charged only half of this protection cost. The inventory and marking would cover only that part of the forest to be cut over, 1,734 acres, and would include only those trees over 13 inches d.b.h. The cost would average about $0.20 per acre. General administration of the forest, which would be a part of that of the whole subsistence homestead, amounts to $0.02 per acre. The planting of one-tenth of the idle land, 133 acres, for each of 10 years would cost about $5.00 per acre, including cost of seedlings and wages. The total annual cost is $2,512, or approximately $0.25 per acre. This cost closely approximates the value of the stumpage cut, which is $2,472, based upon the current stumpage values of pine and hardwood at $2.50 and $2.00 per thousand board feet respectively. Five hundred and forty man-days of labor would be provided by the different cost items during the year: Fire protection, 200; inventory and marking, 100; administration, 40; and planting, 200.

Table 18.—Annual costs on a community forest in Jasper County, Ga.

Item	Area covered	Man-days required	Cost	
			Per acre	Total
	Acres	Number	- - - - - - Dollars - - - - -	
Taxes	10,000	-	.08	800.00
Fire protection	10,000	200	.05	500.00
Inventory and marking	1,734	100	.20	347.00
Administration	10,000	40	.02	200.00
Planting	133	200	5.00	665.00
		540		2,512.00

As shown in the preceding paragraphs, the incomes and costs during the first few years on the community forest will show neither profit nor loss. Although there will be no surplus representing interest on the value of the forest investment, an annual total of 4,650 man-days of labor will be furnished; 1,060,000 board feet of lumber, 927 cords of fuel wood, and 7,410 fence posts will be produced and sold at cost to subsistence homesteaders for their home use. Meanwhile the forest will have been put in better growing condition, so that a future yield of greater volume, higher quality, and more valuable products can be expected. Unquestionably, the annual yield of stumpage from this forest can be increased at least three, probably four or more times in volume, and still more in value.

In addition to the money values of the forest's products, its value in preventing soil from washing away is considerable. Other important forest possibilities include the propagation of fish and game as an item of food for the homesteaders, the grazing of livestock and dairy cattle, and recreation.

USE OF FORESTS FOR SOIL PROTECTION, GAME MANAGEMENT, RECREATION, AND GRAZING

Use of Forests for Soil Protection

The actual returns from a forest are more than the yields in wood products. Soil protection and soil reconstruction, fish and game production, recreation, and grazing of livestock are some of the other uses of a forest from which either direct or indirect returns are received.

Among the most important uses of the forests in the Lower Piedmont Region are the protection of soil against erosion and the reconstruction of soil that has been badly washed by sheet and gully erosion. Since such a large part of the abandoned land has been eroded and so much of it has reverted to forests, a study was made of the effects of forests in checking erosion. Records of active and arrested erosion were taken on 924 $\frac{1}{4}$-acre forest plots in old-field pine stands and on 512 forest plots in natural forest stands other than old-field. About 4 percent of all forest plots showed active or unarrested erosion. In the old-field pine forests of the six sample areas, 5.3 percent of the plots showed active erosion as compared to only 1.4 percent of the plots in the other types. The investigation showed, as was expected, that active erosion is found mostly in the young timber and in the poorly stocked stands. Undoubtedly, these young stands will in time arrest the active erosion. Some plots that showed active erosion lay just below large fields that drained through the forest plot, the drainage resulting in active gullying. Fire, which burns off the pine needles and other vegetative cover, frequently opens the area to sheet erosion.

Forest plots with arrested erosion were classified in the following four groups, depending on the degree of erosion which, though arrested, was still apparent: Sheet #1—no apparent erosion, or mild sheet erosion with less than 30 percent of the B soil horizon exposed; sheet #2—serious sheet erosion with more than 30 percent of the B soil horizon exposed; gully #1—occasional gullies; gully #2—heavily gullied area unfit for agriculture. In old-field pine, 94.7 percent of the forest plots showed arrested erosion, divided as follows among the four grades of erosion: Sheet #1, 40.3 percent; sheet #2, 16.5 percent; gully #1, 29.0 percent; and gully #2, 8.9 percent. In other than old-field forests, 98.6 percent of the forest plots showed arrested erosion, divided as follows: Sheet #1, 87.3 percent; sheet #2, 2.5 percent; gully #1, 7.8 percent; and gully #2, 1.0 percent. Table 19 shows these erosion conditions by classes of stands for the six sample areas as a whole; table 20 shows erosion conditions for each of the six sample units. On areas with arrested erosion, the trees and other vegetation are gradually rebuilding a fertile layer of topsoil upon the impoverished soils they reclaim.

An interesting contrast of soils was found in Jasper County near Monticello. A natural forest that never had been cleared had a layer of topsoil, or A-horizon soil, about 12 inches deep. At the edge of the forest the A horizon disappeared abruptly with the beginning of the adjoining cultivated field where sheet erosion was active.

With an Abney hand level, the slope was ascertained for almost all plots on the line-plot survey. The forest plots were then classified into the following slope-percent classes: 0-3 percent, 3 to 7 percent, 7 to 12 percent, and over 12 percent. Table 21 shows the relationship between the degree of slope and class of erosion and the class of stand. Slope data for the old-field pine type, taken on 918 plots, are distributed as follows: 10.8 percent of the areas had slopes of 3 percent or less; 43.2 percent had slopes between 3 and 7 percent; 30.6 percent had slopes between 7 and 12 percent; and 15.4 percent had slopes over 12 percent. Ordinarily, as shown in the old-field pine plots in the different slope classifications, the steeper the degree of slope, the greater the erosion has been in the past. Eighty percent of the old-field pine plots having the steepest slopes (12 percent and over) showed evidence of serious sheet or gully erosion in the past, whereas only 3 percent of the plots on gentle slopes showed signs of serious erosion now arrested.

Table 19.—Percent of forest plots with active and arrested erosion by classes of forest stands for the six sample areas as a whole

Class of stand	Active erosion	Erosion arrested				Total	Basis, plots
		Sheet #1[1]	Sheet #2	Gully #1	Gully #2		
	- - - - - - - - - -	Percent of total	- - - - - - - - - -				Number
Old-field pine type:							
Saw timber, well stocked	1.5	39.6	14.3	31.2	13.6	100	154
Young, well stocked	5.9	46.1	20.4	21.7	5.9	100	152
Saw timber, medium stocked	2.0	29.8	17.2	36.4	14.6	100	198
Young, medium stocked	11.3	44.4	15.0	25.6	3.7	100	133
Saw timber, poorly stocked	1.7	39.0	18.6	33.9	6.8	100	118
Young, poorly stocked	10.0	45.6	14.2	24.3	5.9	100	169
Averages and total	5.3	40.3	16.5	29.0	8.9	100	924
Pine-hardwood type:							
Saw timber	1.9	89.8	.9	7.4	-	100	108
Young	2.1	81.1	2.1	14.7	1.0	100	95
Upland pine type:							
Saw timber	-	78.6	7.1	10.7	3.6	100	84
Young	2.7	83.5	3.7	9.2	.9	100	109
Bottomland hardwood type	-	100.0	-	-	-	100	116
Averages and total	1.4	87.3	2.5	7.8	1.0	100	512

[1] Sheet #1 includes plots with no apparent erosion or with mild sheet erosion.

Table 20.—Percent of forest plots with active and arrested erosion in each of the six sample areas

Sample areas	Active erosion	Erosion arrested				Total	Basis, plots
		Sheet #1	Sheet #2	Gully #1	Gully #2		
	Percent of total						Number
Old-field pine type:							
Jasper	6.6	44.8	14.8	26.2	7.6	100	183
Monroe	5.5	31.3	23.1	29.1	11.0	100	182
Wilkes A.	4.1	61.0	13.7	15.7	5.5	100	146
Wilkes P.	1.7	48.3	14.6	34.5	.9	100	116
Meriwether	5.1	38.7	7.4	36.9	11.9	100	176
Morgan	8.3	16.5	28.1	32.2	14.9	100	121
Averages and total	5.3	40.3	16.5	29.0	8.9	100	924
Other than old-field pine type:							
Jasper	2.5	80.2	2.5	13.6	1.2	100	81
Monroe	-	89.4	3.2	7.4	-	100	94
Wilkes A.	-	87.6	2.5	9.9	-	100	81
Wilkes P.	2.7	84.9	5.5	6.9	-	100	73
Meriwether	2.3	92.0	-	5.7	-	100	88
Morgan	1.1	88.4	2.1	4.2	4.2	100	95
Averages and total	1.4	87.3	2.5	7.8	1.0	100	512

Fish and Game Production and Recreation

The propagation of fish and game, which does not interfere with other uses of the forest, can be made an important part of the management of forests in the Lower Piedmont Region. Most streams are already fairly well stocked with fish, and the land supports numerous rabbits, squirrels, quail, raccoon, and opossum. Fish and game now constitute a part of the food used by the population, and this free food could be considerably increased.

The most important management measures are those designed to protect fish and game through strict observance of fishing and hunting seasons and through the limitation of the catch or kill. People in this region are more interested in fish and game for food than for sport (although the latter is important); hence the propagation of food fish, such as channel-cat, red-horse, drum, and buffalo, should be encouraged in the streams and ponds, along with such game as rabbits, squirrels, quail, and opossum in the forest. The sale of hunting and fishing rights also affords an opportunity of obtaining a cash income from game management; but before this is possible, game fish, such as black bass, and wild game, such as quail, wild turkey, deer, and valuable fur-bearing animals, must be stocked. Both food and game fish may be propagated, but in general it may be expedient to allot a separate area for each. The practicability and profitable-

Table 21.—Erosion conditions in the old-field pine type by stand classes and degree of slope for the six sample units considered as a whole
(Basis, 918 plots)

Class of stand	Slope 0 - 3 percent						Slope 3 - 7 percent					
	Active erosion	Erosion checked				Total	Active erosion	Erosion checked				Total
		Sheet #1	Sheet #2	Gully #1	Gully #2			Sheet #1	Sheet #2	Gully #1	Gully #2	
	Percent of total											
Old-field pine type:												
Saw timber, well stkd.	7.3	-	-	-	7.3	-	24.5	4.0	11.9	2.0	42.4	
Young, well stkd.	17.2	-	-	-	17.2	2.0	23.8	11.9	10.6	.7	49.0	
Saw timber, med. stkd.	7.7	-	-	-	7.7	.5	17.3	5.6	12.8	1.0	37.2	
Young, med. stkd.	9.8	.8	.7	-	11.3	5.2	28.6	8.3	12.8	.7	55.6	
Saw timber, poorly stkd.	9.3	-	-	-	9.3	.9	19.5	5.1	11.0	.8	37.3	
Young, poorly stkd.	11.8	.6	-	-	12.4	4.7	23.1	1.8	10.0	.6	40.2	
Percent of grand total	10.5	.2	.1	-	10.8	2.2	22.5	6.0	11.5	1.0	45.2	
Percent of individual slope totals	97.0	2.0	1.0	-	100.0	5.0	52.1	13.9	26.7	2.3	100.0	

Class of stand	Slope 7 - 12 percent						Slope 12 percent and over					
	Active erosion	Erosion checked				Total	Active erosion	Erosion checked				Total
		Sheet #1	Sheet #2	Gully #1	Gully #2			Sheet #1	Sheet #2	Gully #1	Gully #2	
	Percent of total											
Old-field pine type:												
Saw timber, well stkd.	.7	6.6	8.6	10.6	5.3	31.8	.7	1.3	2.0	8.6	5.9	18.5
Young, well stkd.	2.0	5.3	6.0	10.6	2.6	26.5	1.3	-	2.7	.7	2.6	7.3
Saw timber, med. stkd.	-	3.6	8.7	16.8	6.1	35.2	1.5	1.5	3.1	6.1	7.7	19.9
Young, med. stkd.	4.5	5.3	3.0	11.3	.7	24.8	1.5	.7	3.0	.8	2.3	8.3
Saw timber, poorly stkd.	.9	7.6	7.6	15.3	2.5	33.9	-	2.6	5.9	7.6	3.4	19.5
Young, poorly stkd.	2.4	7.7	7.1	11.2	1.8	30.2	3.0	3.0	4.7	3.0	3.5	17.2
Percent of grand total	1.6	5.9	7.0	12.7	3.4	30.6	1.4	1.5	3.5	4.5	4.5	15.4
Percent of individual slope totals	5.4	19.2	22.8	41.6	11.0	100.0	9.2	9.9	22.7	29.1	29.1	100.0

ness of game management have been demonstrated in southern Georgia and northern Florida, where large tracts have been leased to hunting clubs. On other tracts a fee is charged for hunting. Valuable assistance in game management may be obtained by cooperating with such public agencies as the Georgia State Fish and Game Department, the Georgia Forest Service, the United States Biological Survey, and the United States Bureau of Fisheries.

Except for fishing and hunting, the forests of this region will scarcely be used extensively for recreation. The streams are mostly unsatisfactory for swimming, and the climate is not conducive to summer camping.

Grazing

Individual farmers use the forests and idle land as a range for a few livestock. Grazing, however, is not a large industry in this region and probably will not be of much importance in the future. As forests claim the idle land, and as stocking becomes heavier under fire protection and forest management, the value of the forest as a range for cattle and other livestock will become less and less.

SUMMARY

The Lower Piedmont Region of Georgia includes 35 counties located just north of the fall line in the central part of the State. More than four-fifths of the region has been cleared at one time or another, but owing to the inroads of the boll weevil and the destructive methods of cultivation that have resulted in serious erosion of the soil, a large part of the total area has been abandoned for cultivation and has reforested to old-field pine. Approximately 56 percent of the area was in woodland in 1930, and 43 percent was in cleared land; but only half the cleared land yielded harvest crops. About 40 percent of the cleared land (17 percent of the total area of the region) was idle, and 70 percent of this idle land (12 percent of the total region) was unfit for agriculture. Slightly more than two-thirds of the forested area was in old-field pine stands, about 10 percent was in ridge stands of upland pine and hardwoods, 11 percent was in branch-head and second-bottom pine and hardwoods, and 11 percent was in bottomland hardwoods. Owing chiefly to the heavy cutting of salable timber by farmers who needed a cash income to supplement their diminished crop incomes, most timber stands are poorly stocked with saw-timber trees. Stands are also commonly understocked as to total number of trees. The quality of timber is accordingly poor, resulting in a small annual increment of saw timber and low stumpage values. The financial possibilities at present are not very attractive, but with management these forests should yield much better returns as well as a satisfactory profit.

In January 1934, 220 small sawmills in this region were allotted production quotas under the Lumber Code totaling 14,128,000 board feet of lumber and involving 42,384 man-days of employment per month. A concentration yard with a planing mill and small portable mills scattered in the better patches of timber is the common setup for lumbering. "Roofers," which sell for about $20 per thousand board feet, are the chief product. About three 8-hour man-days are required to log and mill 1,000 board feet of lumber.

A farm in Meriwether County illustrates the financial possibilities of farm woodlands. It has 230 acres of forested land of the following classes: Old-field pine, 160 acres; upland pine and hardwoods, 18 acres; branch-head and second-bottom pine and hardwoods, 32 acres; bottomland hardwoods, 20 acres. In addition, it has 17 acres of idle land, unsuited to agriculture, which should be planted to forest trees. The per-acre volumes and present annual increment of the well-stocked old-field pine stands are 3,339 and 237 board feet respectively; those of poorly stocked stands are 1,435 and 97 board feet respectively. The present current per-acre stumpage values of the annual increment in well-stocked and poorly stocked stands are $0.59 and $0.24 respectively. The total annual increment of saw timber on the farm is 22,670 board feet of pine and 5,613 board feet of hardwoods; and the total value of this increment, which is also the allowable cut, is 67.91, or $0.30 per acre of forested area. In addition to saw timber, 22 cords of fuel wood and 154 fence posts can be cut from the tops of felled saw-timber trees and from the trees removed in making improvement cuttings and thinnings. The farmer will need the fence posts and about 12 cords of the fuel wood for use on the farm, but he can sell the other 10 cords for $20.00 cash. The annual costs of forest management for the farm woodland are: $0.14 per acre, or $32.20 for 230 acres, as a cash payment for taxes; 3 man-days' labor in fire protection; 26 man-days in improvement cuttings, thinning, and marking for harvest cutting. The cost per acre of planting the idle land is $2.00 for planting stock and 1½ man-days' labor in planting.

A study of financial possibilities of present stands on a 10,000-acre subsistence homestead community forest—on which the homesteaders furnish all labor for forestry activities, logging and manufacturing; pay, in addition to their contributed labor, the current stumpage value for the timber utilized; and receive in return the forest products—showed that incomes and expenses would balance. The forest products making up the annual cut are: 707,330 board feet of pine lumber; 352,210 board feet of hardwood lumber; 2,210 pine fence posts; 5,200 hardwood fence posts; 575 cords of pine fuel wood; and 353 cords of hardwood fuel wood. The total value of the stumpage, with pine at $2.50 and hardwood at $2.00 per thousand board feet, is $2,472, or $0.25 per acre. The annual costs of forest management and of producing forest stumpage are: $0.08 per acre, or $800 for taxes; $0.05 per acre, or $500 for fire protection; $665 for planting stock and labor to plant 133 acres; $0.20 per acre, or $347 for inventory and marking the annual cut on 1,734 acres; $0.02 per acre, or $200 for administration; a total of $2,512 or $0.25 per acre. A total of 4,650 man-days of labor will be furnished annually to subsistence homesteaders in management activities and in manufacturing forest products.

The plots taken in this study indicate very little active erosion in the forest, even though much of the forest is old-field pine that has reestablished itself upon seriously eroded field. The forest's ability to arrest soil erosion is therefore evident; only 5.3 percent of the old-field pine stands and 1.4 percent of the natural forest stands other than old-field showed active erosion. It was found also in old-field pine stands that 10.8 percent of the areas had slopes less than 3 percent, 43.2 percent had slopes between 3 and 7 percent, 30.6 percent had slopes between 7 and 12 percent, and 15.4 percent had slopes greater than 12 percent. Eighty percent of the old-field pine stands with slopes greater than 12 percent showed evidence of serious erosion in the past, whereas only 3 percent of the areas on gentle slopes showed signs of serious erosion.

The possibilities of using the forest for fish and game production, recreation, and grazing are also worthy of consideration.

APPENDIX

Table 1.—General distribution of land area by major use classes, Lower Piedmont Region, based on 1950 Census of Agriculture

County	Total land area	Agricultural land	Urban areas	Forested land
	Acres			
Baldwin	196,480	67,459	2,305	126,716
Butts	129,920	66,307	2,167	61,446
Clarke	72,960	42,700	3,818	26,442
Clayton	90,880	51,570	1,868	37,442
Columbia	224,000	72,821	1,487	149,692
Coweta	283,520	134,651	5,926	142,943
Elbert	231,040	116,136	3,626	111,278
Fayette	149,760	62,825	1,466	85,469
Greene	266,240	96,796	2,850	166,594
Hancock	339,200	107,807	2,694	228,699
Harris	320,640	97,312	1,623	221,705
Hart	167,040	103,909	2,268	60,863
Henry	207,360	117,245	2,683	87,432
Jasper	205,440	98,547	3,016	103,877
Jones	241,280	95,273	1,832	144,175
Lamar	117,760	61,143	844	55,773
Lincoln	186,240	55,719	1,570	128,951
McDuffie	183,680	65,053	1,518	117,109
Meriwether	317,440	164,281	5,233	147,926
Monroe	300,800	94,967	3,116	202,717
Morgan	249,600	99,429	3,303	146,868
Newton	167,680	92,594	4,135	70,951
Oconee	110,080	66,036	1,513	42,531
Oglethorpe	322,560	127,545	2,628	192,387
Pike	151,680	82,554	3,373	65,753
Putnam	231,040	74,099	1,546	155,395
Rockdale	76,160	48,592	1,112	26,456
Spalding	133,760	76,646	3,372	53,742
Talbot	199,680	82,363	2,562	114,755
Taliaferro	135,680	53,799	875	81,006
Troup	278,400	119,842	6,706	151,852
Upson	202,880	83,726	2,567	116,587
Walton	211,840	130,703	3,639	77,498
Wilkes	293,120	113,134	3,129	176,857
Warren	258,560	104,136	1,714	152,710
Total	7,254,400	3,127,719	94,084	4,032,597
Percent of total	100.0	43.1	1.3	55.6

Table 2.—Height growth and mortality in plantations in the Lower Piedmont Region

No.	Species	Year planted (spring)	Average height May 1933	Maximum height May 1933	Area	Estimated survival May 1933	Notes1/
			Feet	Feet	Acres	Percent	
a	Loblolly pine	1931	4	5	1	90	Eroded old field. Slope over 12%.
b	"	1931	3	4	1	95	Eroded old field.
c	"	1931	2½	4	10	95	Eroded old field. Slope 20%.
d	"	1930	5	7	1	95	Planted with alternate rows of cowpeas.
e	"	1930	4	6	1	98	Eroded abandoned pasture. Slope 7-12%.
f	"	1933	½	1½	3	98	Dry, sandy old field. Slope 7-12%.
g	"	1927	19	21	1	95	Planted 6 x 8 feet on fair site.
h	"	1929	8	12	10	95	Poor soil. Gully slope over 12%.
i	"	1929	8	13	1	95	Fair level site. Spacing 6 x 6 feet.
j	"	1930	7	11	1	95	Fair level site.
k	"	1929	3½	5	3	90	Fair level site.
k (1)	"	1929	4½	9	3	-	Direct seeding excellent stan caught on fair site. Pine straw added.
k (2)	"	1933	-	-	-	-	Direct seeding apparently a failure.
l	"	1930	3	5	1	92	Tip moth damage. Planted 3 x 4 feet.
m	"	1928	6	11	3	85	Poor site, crowded spacing 3 x 4 feet.
n	"	1930	3	8	1	75	Good level site. Spacing 6 x 8 feet. Tip moth damage.
o	"	1931	2½	3	40	80	Poor steep site. Dense vegetation.
a	Slash pine	1931	2½	4	20	95	Poor old-field site. Slope over 12%.
b	"	1931	3	4	3	90	Poor, dry old-field site. Slope over 12%.
c	"	1931	3	4	2	95	Poor, gullied slope.
d	"	1931	2½	3½	10	95	Eroded clay soil. Slope over 15%, spacing 6x8 feet.
e	"	1931	3	4½	20	65	Mountainous site. Rocky and dry. Slope over 12%.
f	"	1931	2½	4	7	72	Dry, sandy site. Spacing 6 x 8 feet.
g	"	1931	4	6	8	85	Fair site. Slope 3-7%, spacing 6 x 10 feet.
h	"	1931	2	3	10	50	Poor site. Vegetation dense.

1/ See footnotes on next page.

Table 2.—Height growth and mortality in plantations in the Lower Piedmont Region—Continued

No.	Species	Year planted (spring)	Average height May 1933	Maximum height May 1933	Area	Estimated survival May 1933	Notes[1]
			Feet	Feet	Acres	Percent	
a	Longleaf pine	1928	4	8	10	90	Good site, spacing 6 x 8 feet.
b	"	1932	2	3½	10	90	Good site. Slope 5%. Spacing 7 x 7.
c	"	1931	1	2	7	85	Poor, eroded site. Spacing 8 x 8.
d	"	1929	3	6	10	70	Poor mountainous site. Slope 10%.
e	"	1931	1	2	1	50	Fair site.
f	"	1931	½	1	100	25	Poor, badly eroded site. Dense vegetation.
a	(Red cedar	1932	3	4	1	90	Old eroded field. Slope over 12%.
	(Black locust	1932	3	4	-	90	
b	(Tulip poplar	1932	1½	3	1	75	Fair site. Vegetation dense.
	(Loblolly	1931	4	5	-	90	
c	(Slash	1931	2½	3½	1	95	Eroded hillside old field.
	(Loblolly	1931	2½	3½	-	95	
d	(Slash	1931	2½	4	10	95	Old field on eroded slope. Vegetation dense.
	(Loblolly	1931	2½	4	-	-	
e	Black locust	1923	27	40[2]	1	98	Crowded in planting 6 x 6. Fair site, Damaged by vines.
f	Black locust	1931	7	13	3	90	Poor mountainous site.

[1] All except two of the plantations were established by planting seedlings; the exceptions were direct seedlings.

[2] The maximum diameter 4.5 feet above ground is 6 inches and some of the trees are large enough to yield 3 or 4 small fence posts of excellent quality.

Editor's Note.—This is a multilithed reissue of the original multigraphed paper. Some typographical and mechanical alterations have been made, but the data and other essentials remain unchanged.

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OCCASIONAL PAPER No. 54 December 4, 1935.

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GROWTH AND YIELD OF SECOND-GROWTH RED GUM IN FULLY STOCKED STANDS ON ALLUVIAL LANDS IN THE SOUTH

By

ROBERT K. WINTERS, *Forester,*

and

JAMES G. OSBORNE, *Assistant Silviculturist*

This paper releases data gathered in current investigations of the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

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INTRODUCTION

GENERAL

The natural range of red gum (*Liquidambar styraciflua* Linn.) includes the eastern United States from Connecticut to the Trinity River, Texas, and the interior as far north as southern Ohio and Indiana. In the maritime region of the South Atlantic and Gulf States and the Mississippi River Delta, it grew to large size in the original timber stands on the better-drained, silty-clay, bottomland soils. Red gum in virgin hardwood forests seldom grew in pure stands over extensive areas, but usually was found in mixture with other species.

PURPOSE AND SCOPE OF STUDY

On account of the wide distribution, large aggregate volume, and present commercial importance of red gum timber, a study of its growth rate and yield in fully stocked, even-aged, second-growth stands was undertaken by the Southern Forest Experiment Station of the U. S. Forest Service in 1931, the field work of which was completed in 1933. At the outset this study was confined to the Delta region of the Mississippi River; but since second-growth red gum stands are commonly found on the alluvial bottomlands of other southern streams that flow into the Atlantic Ocean and Gulf of Mexico, the scope of the study was extended to these lands. The results therefore apply to second-growth red gum grown in fully stocked stands on alluvial bottomlands throughout the South. Field data were gathered on plots in stands distributed as shown in figure 1.

CHARACTERISTICS OF STANDS STUDIED

Stands in this study were classified as "red gum" if 90 percent or more of the largest and best developed trees were red gum. Although second-growth red gum stands occupy a considerable area in the South, only a small percentage of this area is even-aged and fully stocked. Theoretically, fully stocked stands are those in which the tree crowns form a complete and unbroken canopy. As a rule, however, such stands contain a few small openings. Stands were considered to be even-aged if the age variation among the dominant and codominant trees was not greater than 8 to 10 years.

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[1] Acknowledgement is gratefully given Mr. V. B. Davis, Associate Forest Economist, Southern Forest Experiment Station, who was in personal charge of the major part of the field work. Acknowledgement is also due Mr. F. X. Schumacher, Silviculturist, U. S. Forest Service, and Mr. R. A. Chapman, Assistant Silviculturist, Southern Forest Experiment Station, who gave valuable assistance throughout the analysis of the data.

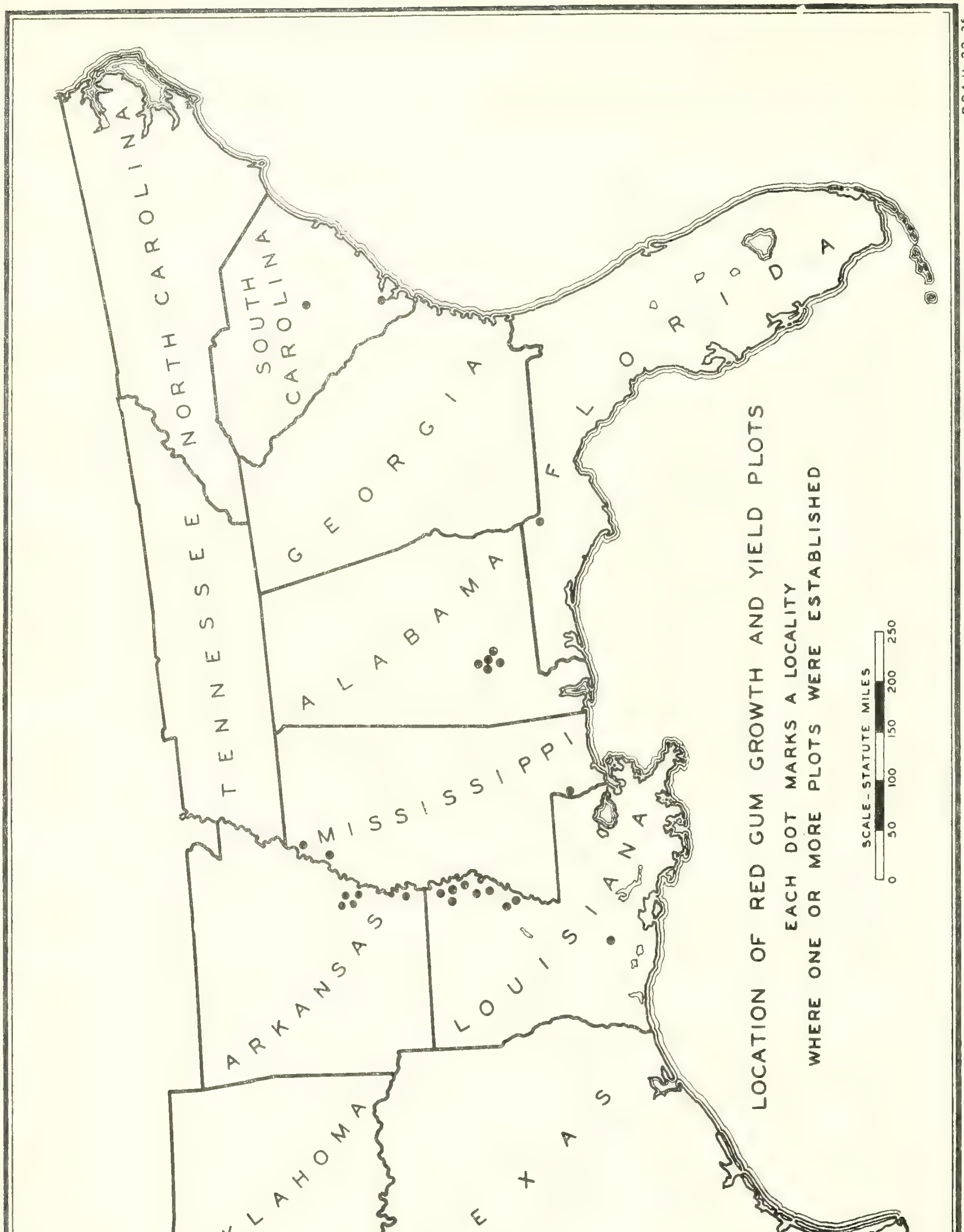
LOCATION OF RED GUM GROWTH AND YIELD PLOTS
EACH DOT MARKS A LOCALITY WHERE ONE OR MORE PLOTS WERE ESTABLISHED
SCALE - STATUTE MILES
0
50
100
150
200
250
SOUTHERN FOREST EXPERIMENT STATION - NEW ORLEANS, LA.
R.D.A. 11-22-35
NORTH CAROLINA
SOUTH CAROLINA
TENNESSEE
GEORGIA
ALABAMA
FLORIDA
MISSISSIPPI
ARKANSAS
LOUISIANA
OKLAHOMA
TEXAS

FIGURE 1.--Red gum growth and yield study areas.

The young red gum tree is able to endure a certain amount of shade and stand crowding; hence the leaf and crown canopy of young stands is usually dense. With increased age, however, trees become less able to endure competition. The most suppressed red gum trees die from crowding and the stands become more open. Following this natural decrease in the density of the crown canopy, sufficient sunlight reaches the ground to permit the development of an understory stand, composed of such species as American elm, hackberry, red maple, hawthorn, deciduous holly, and dogwood. This understory is present in nearly all even-aged, second-growth, red gum stands more than 40 years old. (See figure 2.) Since the trees in the understory do not usually contribute to the merchantable volume of the main stand at the utilization date, they are not considered in the timber yield as shown in table 1.

As nearly as could be learned from the analysis of forest conditions on the growth and yield plots, most of the stands had been burned over at some time during the life of the stand. Light ground fires seldom kill a red gum tree after it is 30 or 40 years old, but they do wound the bases of trees and thus facilitate the entrance of decay organisms into the tree stems. Most of the rot found near the base of red gum trees is probably attributable directly or indirectly to fire scarring.

Forest fires of moderate intensity frequently kill nearly all the trees in stands less than 10 to 15 years old. At this age red gum sprouts vigorously, however, and the stand that subsequently develops may be either partly or entirely of sprout origin, depending upon the completeness with which the original seedling stand was destroyed by fire. The early height growth of the red gum sprouts from a vigorous root system is exceedingly rapid. Seedlings require, on the average, 3 to 5 years to reach breast height, whereas sprouts from vigorous root stocks frequently reach breast height at the end of the first growing season. Although the duration of this accelerated growth has not been specifically determined, 10-year-old red gum sprouts frequently have the size and general appearance of 18-to 20-year-old seedlings in the same stand. Red gum stands of mixed sprout and seedling origin are readily identified by the presence of "twins", that is, two or more trees that have sprouted from a single root stock. (See figures 3 and 4.)

DEFINITION OF TERMS

Diameter at breast height.--The outside-bark diameter of a standing tree measured 4.5 feet above the ground. This term is commonly abbreviated to d.b.h.

Number of trees.--All trees above a minimum stated d.b.h. that are considered to be a part of the even-aged stand. This concept of number of trees excludes trees of species that generally form the understory characteristic of even-aged red gum stands more than 40 years old.

Basal area.--The area in square feet of a cross-section of a tree measured at breast height. The basal area of a stand is the sum of the basal areas of the trees of which it is composed.

Average diameter at breast height.--The diameter of a tree that has the average basal area of the trees in the stand. The calculation of the average diameter at breast height involves two separate operations: (*a*) Dividing the basal area of a stand by the number of trees it contains to obtain the average-tree basal area; and (*b*) Determining, by reference to standard tables, the tree diameter in inches that corresponds to this average basal area.

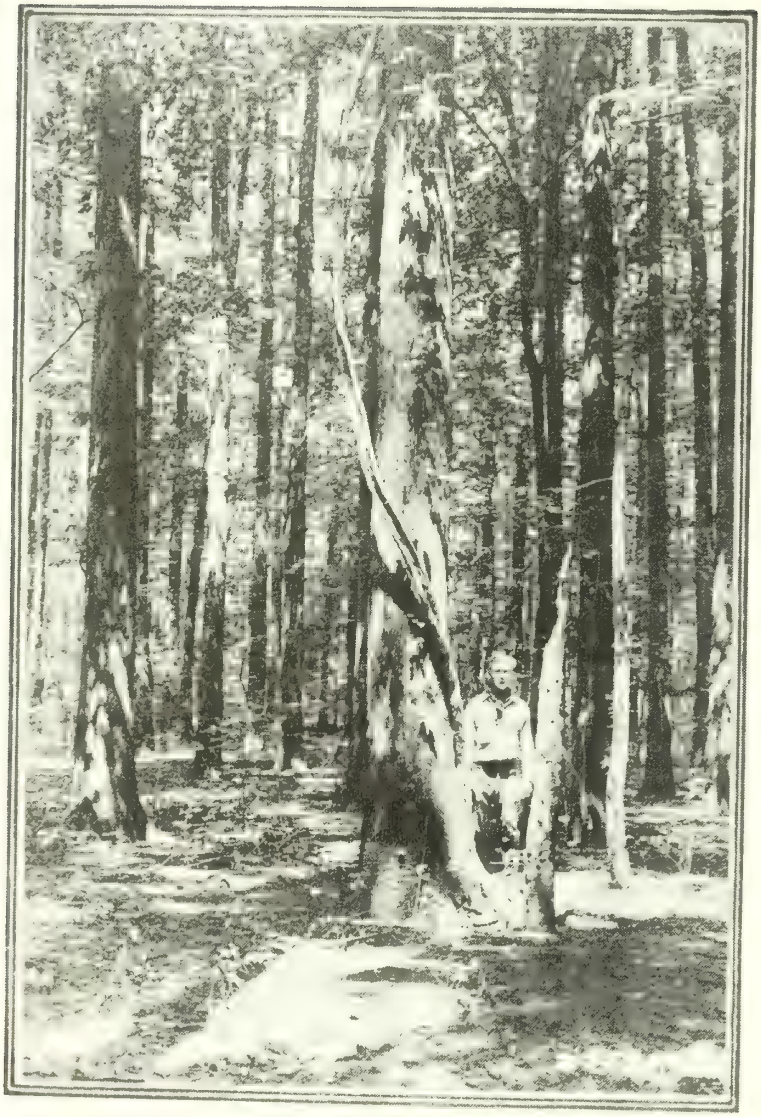

FIGURE 2.--A 67-year-old red gum stand in southern Mississippi. Note the conspicuous understory that has developed beneath the maturing stand.

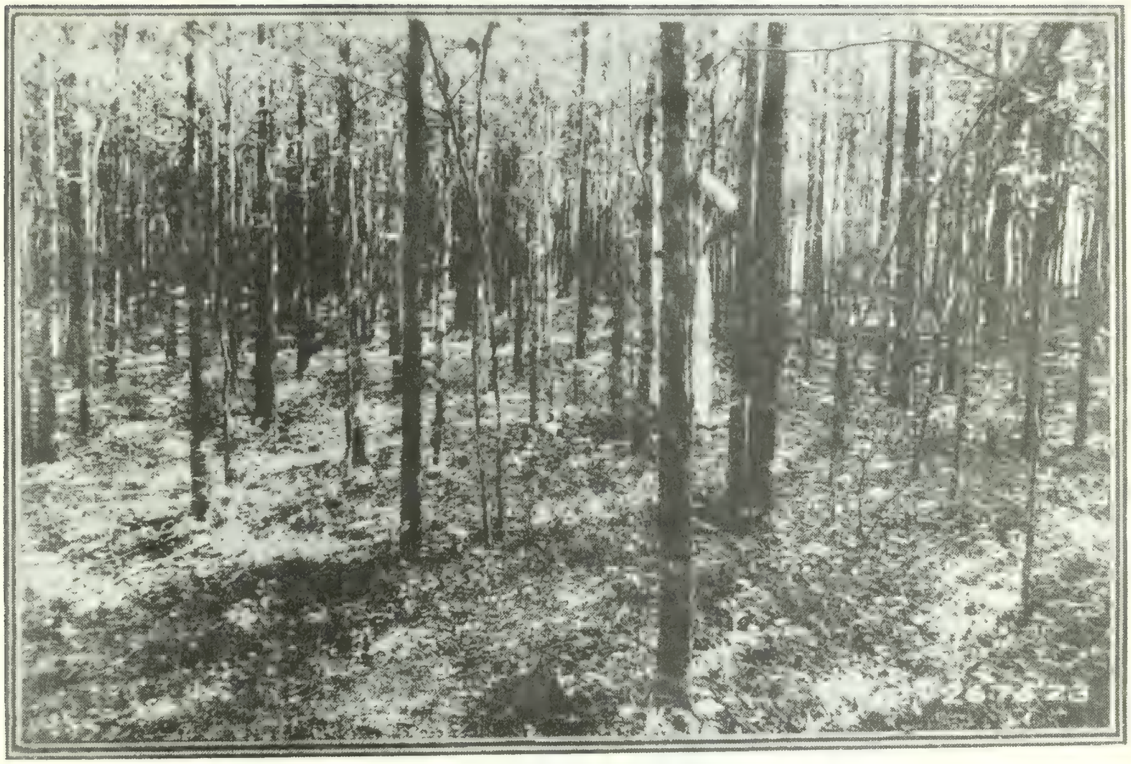

FIGURE 3.--An even-aged, second-growth stand of young red gum. This 14-year-old stand in northern Louisiana developed on an abandoned cotton field. Note the "twin" trees that indicate the sprout origin of at least a part of the stand.

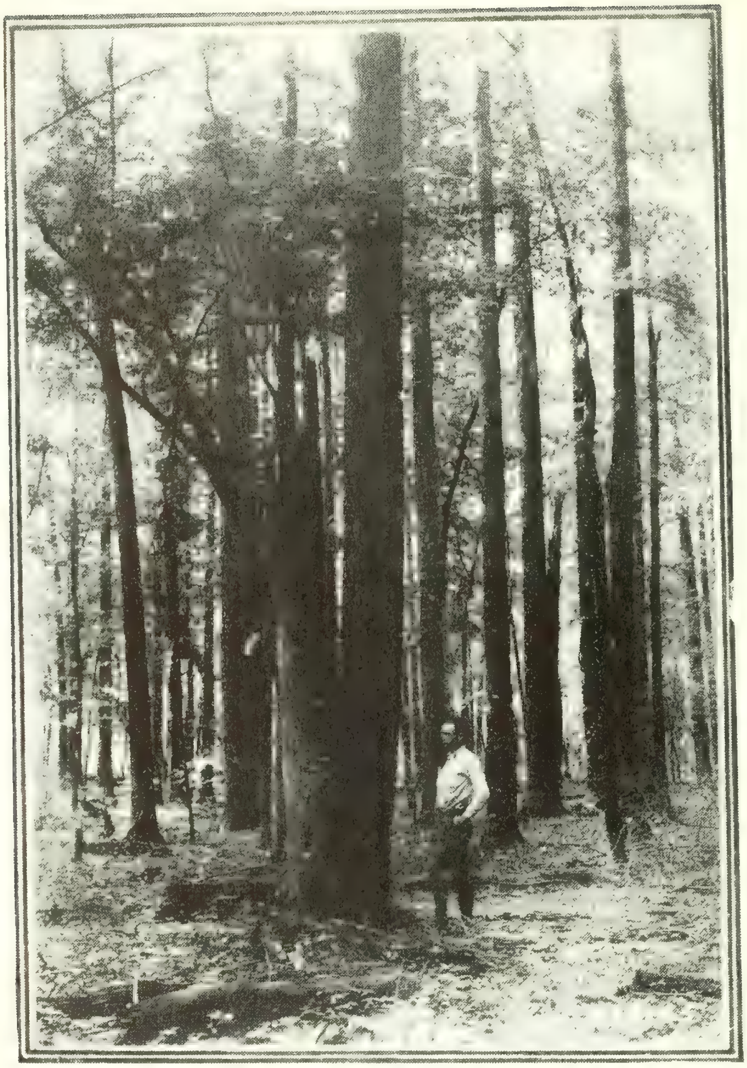

FIGURE 4.--A 99-year-old second-growth red gum stand in southeastern Alabama. Note that the tree in the foreground developed as a "twin".

Dominant.--Any tree with a well formed crown that receives full sunlight from above and at least some light from the side. The dominant classification, as used in this study, includes both the dominant and codominant trees, as ordinarily defined.

Stand age.--The average age at breast height of 5 to 10 dominant trees considered to be representative of the stand.

Site quality.--The relative wood-producing capacity of a given area, measured in this study by the height growth of the average dominant red gum.

Site index.--A measure of site quality. In this study site index is the height attained by the average dominant tree 50 years of age at breast height.

Merchantable tree.--Any tree over 12.5 inches in diameter at breast height that contains one merchantable log (see below) at least 12 feet long.

APPLICATION OF GROWTH AND YIELD DATA

The growth and yield figures that follow are intended for use in calculating the growth and yield of even-aged, fully stocked, second-growth red gum stands found on the alluvial bottomlands of the South. They cannot properly be applied to stands that do not meet these specifications. Since stands can deviate from these so-called "normal" stands in a number of ways, no specific corrections can be given to make these tables apply to partially stocked stands or to uneven-aged stands or to stands of mixed species. Skilled men, who know red gum timber stands and the laws of forest growth, can sometimes make approximate predictions for "unnormal" stands that do not deviate too greatly from the normal.

MERCHANTABLE STAND

DESCRIPTION OF LOG GRADES

Log grades used by the Southern hardwood industry vary greatly throughout the region, depending upon locality and fluctuations in the hardwood lumber market. The following grades for merchantable logs, developed by the Southern Forest Survey, have been used in this study:

Grade 1.--A sound log[2] at least 12 feet long and 16 inches in diameter inside bark at the small end, from which at least 70 percent[3] of the volume can be cut into number 1 common lumber or better (either sap gum or red gum).

Grade 2.--A sound log at least 12 feet long and 12 inches in diameter inside bark at the small end, from which 35 to 69 percent[3] of the volume can be cut into number 1 common lumber or better (either sap gum or red gum).

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[2] A sound log is one that has at least 50 percent of its volume in sound material.

[3] These percentages are the minimum for the given grade. A run of number 1 logs, for example, will yield more than 70 percent of their aggregate volume in number 1 common lumber or better.

Grade 3.--A sound log at least 12 feet long and 9 inches in diameter inside bark at the small end, which cannot be classified as grade 2 because of either size or sweep. A log of this grade is especially suitable for the production of barrel staves and small dimension stock.

Grade 4.--A sound log at least 12 feet long and 10 inches[4] in diameter inside bark at the small end, which cannot be classified as grade 3 or better because of size or quality. At least 50 percent of its volume must be suitable for ties, timbers, or rough structural material. Logs of this grade are usually rough and knotty, and may be of any diameter above the minimum specified.

UTILIZATION PRACTICES

Although logs that meet the requirements of the preceding specifications are considered merchantable throughout this report, the average hardwood-lumber mill operator would not use all of the logs in all of the log grades. Casual inspection of cutting operations in fully stocked, even-aged, second-growth red gum stands indicates that a considerable quantity of material classified as log grade 4 is commonly left in the woods after a lumber-mill or barrel-stave cutting operation.[5]

FIELD MEASUREMENTS

On each sample plot established in this study, the breast-high diameter of each tree was measured with calipers. Ocular estimates were made also of the length and of the inside-bark diameter at the top end of each merchantable log in each tree. Each log was graded in accordance with the log-grade definitions given above, the merchantable length of each tree being divided into 12-, 14-, and 16-foot logs in such a way as to obtain a minimum volume in low-grade logs. The merchantable length of a given tree depended upon the limbiness or knottiness of the upper part of the stem, and incuded only such part as could be graded log grade 4 or better. Although the diameter inside bark at the top of the highest log varied from tree to tree, it was seldom less than 10 inches. An occasional 9 inch log was included in the volume of log grades 3 and 4.

In estimating board foot volumes of individual trees, that quantity of defective stem material was excluded which, according to generally accepted logging practice, would be left unutilized in the woods. Accordingly, the volume of cull sections was

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[4] An occasional 9-inch log of better-than-average quality was included in this grade.

[5] The following data were obtained on a selected acre plot in a fully stocked, even-aged, second-growth red gum stand. The timber was cut for lumber-mill utilization and the data are presented here for what they may be worth. Woods-utilization practice on this area is thought to be somewhat closer than is usual in similar stands of red gum elsewhere in the South.

Age of stand at breast height	67 years
Average total height of dominant trees in stand	111 feet
Volume in standing trees before logging	14,189 bd. ft. per acre (Scribner log scale)
Volume in trees cut	6,890 bd. ft.
Percentage of total volume felled	49 percent
Percentage of felled material hauled to mill	73 percent
Percentage of felled material left in woods (including volume of wood split or otherwise damaged in felling)	27 percent

deducted from all badly fire-scarred trees and from partially rotten, crooked, or forked trees. The tables of merchantable volume show the gross contents of merchantable logs, and include the cull that is ordinarily carried to the mill in the log. Experience indicates that this cull amounts to approximately 1 percent in the stands studied.

MERCHANTABLE YIELD AND VOLUME TABLES

In the analysis of the field data taken on each plot bearing trees of merchantable size, both the Doyle and the Scribner log rules were applied to the logs by log grades in order to arrive at the plot volume classified by log grades. These plot volumes were weighted and curved to give the average merchantable board-foot yield per acre in stands of different ages and sites. These volumes, together with Doyle and Scribner tree-volume tables and other pertinent data, are shown in tables 1 to 3.

THE USE OF THE MERCHANTABLE YIELD TABLES

These tables are useful chiefly for predicting timber yields by log grades in fully stocked, even-aged, red gum stands. To use these tables for this purpose, it is first necessary to determine the age and average height of dominant trees, and the degree of stocking of the stands for which such forecasts are to be made. Average stand age can be determined by counting the annual rings on cores of wood extracted at breast height with an increment borer[6] from the largest and best-developed trees in the stand. The height of these trees should be carefully measured with a Forest Service Abney level[7] or some other instrument of equal accuracy.

Whenever increment borers are not available, approximate age determinations can be made by counting the annual growth rings on freshly cut stumps. One year can be subtracted from stump-height age to get the approximate breast-height age. In the absence of an Abney level or similar instrument, total tree heights can be roughly determined by ocular estimate or preferably by measuring the height of felled trees.

Having determined the age and height of the dominant trees, one may classify the area on which the stand is growing as a good, medium, or poor site. For example, if the height of the dominant trees in a given 60-year-old stand was found to be approximately 108 feet, the site would be of medium quality (see first and second columns of table 1). To ascertain whether the given stand is fully stocked, count the number of merchantable trees (trees more than 12.5 inches in diameter) on a representative acre, and compare that number with the figure given in column 3 of table 1 opposite the 60 in column 1 of the medium-site section. If the number is approximately 76, the stand is fully stocked and the yield tables can be safely applied.

The average acre of this 60-year-old stand growing on a medium site should bear 9,880 board feet (Doyle log rule) of timber of all log grades. Of this volume, 840 board feet per acre should be grade 1; 2,540, grade 2; 2,600, grade 3; and 3,900, grade 4. This statement does not mean that any acre chosen at random from a 60-year-old, fully stocked, second-growth stand can be expected to have exactly this volume divided among grades 1, 2, 3, and 4. The average of a number of such acres should, however, have approximately this total volume, and it should be divided among grades 1, 2, 3, and 4 in approximately the manner indicated in the tables.

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[6] An increment borer is a small (8"-12") auger-like instrument that, by being bored into a tree, can remove a "pencil" of wood. On this core, the rings of growth can be seen, counted, and measured to determine the rate of tree-diameter growth.

[7] A small hand level that can be used to measure tree height or percent of slope.

TABLE 1. -- *Merchantable board-foot volume*[1] *per acre, classified by* ***site, stand-age,*** *and log grades*
(Scribner and Doyle log rules)

POOR SITE - (SITE INDEX 80)

Age at breast-height	Average height of dominant trees	Merchantable trees	Average breast-high diameter of merchantable trees	Basal area of merchantable trees	Volume per acre									
					Scribner Log Rule					Doyle Log Rule				
					Grade 1	Grade 2	Grade 3	Grade 4	Total	Grade 1	Grade 2	Grade 3	Grade 4	Total
Years	Feet	Number	Inches	Sq. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.
40	69	7	14.6	7			70	330	400			20	230	250
50	80	30	14.8	33		60	740	1,200	2,000			520	850	1,370
60	88	49	15.1	57	40	540	1,460	2,030	4,070		500	1,080	1,480	3,060
70	94	62	15.4	75	220	1,240	2,020	2,800	6,280	170	1,080	1,520	2,110	4,880
80	99	71	15.9	88	480	1,960	2,460	3,530	8,430	460	1,640	1,860	2,680	6,640
90	104	77	16.5	98	840	2,700	2,800	4,200	10,540	800	2,260	2,080	3,200	8,340
MEDIUM SITE - (SITE INDEX 100)														
40	89	44	14.8	58		370	1,700	2,190	4,260		310	1,080	1,550	2,940
50	100	64	15.4	91	260	1,510	2,720	3,690	8,180	220	1,390	1,960	2,750	6,320
60	108	76	16.1	115	880	3,040	3,450	5,030	12,400	840	2,540	2,600	3,900	9,880
70	115	86	17.0	133	1,750	4,530	3,970	6,260	16,510	1,630	3,840	3,060	4,960	13,490
80	122	93	17.8	146	2,720	5,930	4,370	7,440	20,460	2,490	4,980	3,420	5,970	16,860
90	127	97	18.6	156	3,700	7,240	4,680	8,500	24,120	3,340	5,960	3,700	6,920	19,920
100	131	99	19.3	163	4,610	8,390	4,940	9,420	27,360	4,180	6,860	3,930	7,820	22,790
GOOD SITE - (SITE INDEX 120)														
30	93	42	14.7	47		110	1,200	2,120	3,430			880	1,460	2,340
40	108	75	15.4	101	250	1,870	3,230	4,500	9,850	200	1,570	2,400	3,300	7,470
50	120	89	16.3	136	1,320	4,160	4,530	6,700	16,710	1,220	3,580	3,450	5,200	13,450
60	129	97	17.4	161	2,800	6,700	5,350	8,770	23,620	2,580	5,620	4,140	6,950	19,290
70	137	103	18.5	179	4,500	9,030	5,950	10,640	30,120	4,080	7,460	4,660	8,680	24,880
80	144	107	19.6	190	6,180	11,000	6,430	12,330	35,940	5,540	8,930	5,100	10,240	29,810

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[1] Including interior rot and other hidden cull. **Sawmill experience indicates that this amounts to approximately 1% of the merchantable volume as shown in the tables.**

Should the owner of this 60-year-old stand wish to harvest his timber at 80 years of age instead of 60, he could expect to secure on the average 16,860 board feet per acre (Doyle log rule). He could reasonably expect 2,490 board feet per acre of this volume to be in grade 1 logs; 4,980 in grade 2; 3,420 in grade 3; and 5,970 in grade 4. Knowing the present average selling price of lumber or other products from logs of the several grades, he can obtain from table 1 the stand-growth information needed in deciding when he should cut his stand.

TABLE 2.--*Board-foot volume table, merchantable volume of second-growth red gum (Doyle rule - merchantable height)*

D.B.H. (inches)	Volume (board feet) by 16-foot log lengths					Basis (trees)
	1	2	3	4	5	
13	33	72	119			287
14	40	86	140			295
15	47	99	159	224		248
16	56	114	179	249	330	236
17	65	130	201	270	370	170
18	74	149	230	319	418	103
19	88	170	256	350	452	88
20	99	193	290	394	510	74
21		215	320	433	560	47
22		246	360	483	620	30
23		284	410	545	700	23
24		320	451	593	750	14
25		362	510	665	835	11
Total						1,626

Constructed by R. A. Chapman by curving merchantable volume over merchantable length by one-inch diameter classes. Stump height 2 feet. Volume based on estimated diameter inside bark at top of logs in standing trees. Log diameter at merchantable limit variable; in general, minimum was 9.6 inches. In the aggregate, tabular volumes are 0.5 percent lower than the basic data. A 3-tenths of a foot trimming allowance was made on each log. Block indicates extent of basic data.

TABLE 3.--*Board-foot volume table, merchantable volume of second-growth red gum (Scribner rule - merchantable height)*

D.B.H. (inches)	Volume (board feet) by 16-foot log lengths					Basis (trees)
	1	2	3	4	5	
13	46	98	156			288
14	51	110	176			299
15	59	126	196	274		253
16	66	140	220	303	403	233
17	77	158	244	332	435	171
18	87	176	271	371	482	100
19	98	199	302	410	532	87
20	115	230	343	461	598	75
21		262	384	510	648	46
22		298	431	568	710	30
23		325	469	610	768	23
24		355	505	650	808	14
25		385	540	678	848	10
Total						1,629

Constructed by R. A. Chapman by curving merchantable volume over merchantable length by one-inch diameter classes. Stump height 2 feet. Volume based on estimated diameter inside bark at top of logs in standing trees. Log diameter at merchantable limit variable; in general, minimum was 9.6 inches. In the aggregate, tabular volumes are 0.5 percent lower than the basic data. A 3-tenths of a foot trimming allowance was made on each log. Block indicates extent of basic data.

APPENDIX

A

TOTAL AND PARTIAL STAND, VOLUME, AND YIELD TABLES.

TABLE 4. -- *Height of average dominant tree*

Age at b.h. (years)	Height (feet) by site index					
	70	80	90	100	110	120
10		17	22	30	39	47
20	31	40	48	57	66	75
30	47	56	66	75	84	93
40	60	69	79	89	98	108
50	70	80	90	100	110	120
60	77	88	98	108	119	129
70		94	105	115	126	137
80		99	110	122	133	144
90		104	115	127	139	
100			119	131	143	

TABLE 5. -- *Number of trees per acre 0.6 inch d.b.h. and larger*

Age at b.h. (years)	Number of trees by site index					
	70	80	90	100	110	120
10		11,900	8,120	5,850	5,120	4,700
20	4,600	3,130	2,150	1,610	1,400	1,290
30	1,760	1,210	865	651	575	530
40	860	598	431	337	303	284
50	512	372	281	225	205	194
60	358	266	209	174	162	155
70		213	174	150	141	136
80		182	154	135	130	126
90		161	140	126	121	
100			129	118	115	

TABLE 6. -- *Average diameter of trees more than 0.6 inch d.b.h., based on diameter breast high of tree of average basal area*

Age at b.h. (years)	Average diameter breast high (inches) by site index					
	70	80	90	100	110	120
10		1.1	1.6	2.0	2.3	2.6
20	1.6	3.0	3.8	4.6	5.1	5.6
30	3.1	4.9	6.2	7.0	7.8	8.4
40	4.6	6.7	8.2	9.2	10.2	11.0
50	6.0	8.4	10.0	11.2	12.3	13.2
60	7.3	10.0	11.6	12.9	14.0	15.0
70		11.3	13.0	14.4	15.6	16.6
80		12.4	14.2	15.6	16.8	17.9
90		13.4	15.3	16.7	18.0	
100			16.2	17.7	19.0	

TABLE 7. -- *Basal area per acre in trees 0.6 inch d.b.h. and larger*

Age at b.h. (years)	Basal area (square feet) by site index					
	70	80	90	100	110	120
10		77	88	99	107	116
20	91	115	132	147	159	172
30	99	126	145	160	174	188
40	102	129	148	164	178	192
50	103	131	150	166	180	195
60	105	132	152	168	183	197
70		134	154	170	185	199
80		135	155	172	186	201
90		136	156	173	187	
100			157	174	189	

TABLE 8. -- *Cubic-foot volume*[1] *per acre of all trees 0.6 inch d.b.h., inside bark, and larger*

(*PEELED WOOD*)

Age at b.h. (years)	Volume (cubic feet) by site index					
	70	80	90	100	110	120
10		450	690	980	1,300	1,620
20	1,100	1,560	2,110	2,750	3,450	4,150
30	1,730	2,370	3,120	3,950	4,900	5,850
40	2,210	2,960	3,860	4,870	5,990	7,130
50	2,600	3,470	4,480	5,660	6,940	8,240
60	2,950	3,900	5,040	6,350	7,790	9,220
70		4,290	5,530	6,950	8,500	10,090
80		4,640	5,960	7,470	9,140	10,830
90		4,980	6,370	7,950	9,700	
100			6,750	8,400	10,220	

[1] This is the inside-bark volume of the main stem, excluding limbs.

TABLE 9. -- *Check of basic data against yield tables for stand 0.6 inch d.b.h. and larger*

Item	Aggregate deviation[1]	Average deviation[2]	Correlation index[3]
	Percent	*Percent*	*Percent*
Basal area per acre	- .076	11.3	.716
Number of trees per acre	- 1.72	24.7	.917
Average diameter at breast height	+ .79	10.8	.965
Volume in cubic feet	- 1.23	11.3	.954

1/ Aggregate deviation in percent is computed from

$$\frac{\text{Sum (Actual)} - \text{Sum (Estimate)}}{\text{Sum (Estimate)}} \times 100.$$

2/ Average percentages deviation is computed from

$$\frac{\text{Sum} \left[\frac{\text{(Actual - Estimate)}}{\text{Estimate}}\right] \times 100.}{\text{Number of plots}}$$

3/ Correlation index = $\sqrt{1 - \left(\frac{\sigma \text{ est.}}{\sigma y}\right)^2}$

Where σ est. = The standard error of estimate.
σ y = Standard deviation of the dependent variable.

TABLE 10. -- *Number of trees per acre 4.6 inches d.b.h. and larger*

Age at b.h. (years)	Number of trees by site index					
	70	80	90	100	110	120
10						190
20		242	549	627	687	738
30	12	540	553	479	467	456
40	336	425	362	307	285	270
50	316	321	260	212	198	189
60	275	249	203	170	160	154
70		205	170	149	141	136
80		176	151	134	128	125
90		157	138	125	121	
100			128	118	115	

TABLE 11. -- *Average diameter of trees 4.6 inches d.b.h. and larger*

Age at b.h. (years)	Average diameter breast high (inches) by site index					
	70	80	90	100	110	120
10						5.5
20		5.6	5.9	6.2	6.5	6.7
30	5.5	6.4	7.1	7.8	8.3	8.8
40	6.2	7.5	8.6	9.6	10.4	11.1
50	7.0	8.9	10.2	11.4	12.4	13.3
60	8.0	10.2	11.8	13.0	14.1	15.1
70		11.5	13.2	14.5	15.7	16.6
80		12.6	14.4	15.8	17.0	17.9
90		13.6	15.4	16.9	18.1	
100			16.3	17.8	19.1	

TABLE 12. -- *Basal area per acre in trees 4.6 inches d.b.h. and larger*

Age at b.h. (years)	Basal area (square feet) by site index					
	70	80	90	100	110	120
10						17
20		32	79	109	129	148
30	4	99	130	150	167	183
40	75	119	143	162	176	192
50	92	127	149	166	180	195
60	100	131	152	168	182	198
70		134	154	170	184	200
80		135	155	172	186	201
90		136	156	173	188	
100			157	174	189	

TABLE 13. -- *Cubic-foot volume*[1] *per acre of all trees 4.6 inches d.b.h. and larger*

(*PEELED WOOD*)

Age at b.h. (years)	Volume (cubic feet) by site index					
	70	80	90	100	110	120
10						180
20		350	850	1,500	2,150	2,850
30	550	1,450	2,300	3,150	4,100	5,050
40	1,400	2,300	3,350	4,300	5,450	6,550
50	1,950	3,000	4,050	5,250	6,500	7,800
60	2,450	3,550	4,650	6,000	7,400	8,800
70		4,000	5,200	6,650	8,100	9,650
80		4,350	5,650	7,200	8,800	10,400
90		4,700	6,050	7,650	9,350	
100			6,450	8,100	9,950	

[1] This is the inside-bark volume of the main stem to a 4 inch top, inside bark, and excludes limbs.

TABLE 14. -- *Number of trees per acre 6.6 inches d.b.h. and larger*

Age at b.h. (years)	Number of trees by site index					
	70	80	90	100	110	120
20			103	180	279	355
30		195	301	300	321	335
40	101	258	260	240	238	237
50	167	235	214	191	184	181
60	183	203	181	162	154	150
70		180	162	144	138	134
80		164	147	131	127	124
90		151	136	123	119	
100			126	116	114	

TABLE 15. -- *Average diameter of trees 6.6 inches d.b.h. and larger*

Age at b.h. (years)	Average diameter breast high (inches) by site index					
	70	80	90	100	110	120
20			7.4	7.6	7.9	8.2
30		7.8	8.4	9.0	9.5	9.9
40	7.6	8.8	9.6	10.5	11.2	11.8
50	8.4	9.9	11.0	12.0	12.8	13.5
60	9.2	11.0	12.3	13.4	14.3	15.2
70		12.0	13.5	14.7	15.7	16.8
80		12.9	14.6	15.9	17.0	18.1
90		13.8	15.6	17.0	18.2	
100			16.4	17.9	19.2	

TABLE 16. -- *Basal area per acre in trees 6.6 inches d.b.h. and larger*

Age at b.h. (years)	Basal area (square feet) by site index					
	70	80	90	100	110	120
20			23	48	73	97
30		51	95	122	144	164
40	33	94	127	150	168	186
50	65	114	141	162	178	194
60	83	124	148	167	182	197
70		130	152	170	184	199
80		134	154	172	186	201
90		136	156	173	187	
100			156	173	188	

TABLE 17. -- *Board-foot volume per acre*[1] *to 5 inch top diameter inside bark, International rule, 1/8 inch saw kerf*

Age at b.h. (years)	Volume (board feet) by site index					
	70	80	90	100	110	120
20			1,000	3,100	5,800	8,800
30		3,400	8,300	12,900	18,700	24,400
40	2,600	9,200	15,600	22,300	30,000	37,500
50	6,500	14,600	22,200	30,300	39,200	48,200
60	10,400	19,300	27,500	36,700	46,900	56,800
70		23,100	31,900	41,900	53,000	64,000
80		26,300	35,900	46,500	58,200	70,000
90		29,300	39,400	50,700	62,700	
100			42,800	54,500	66,800	

[1] This includes all trees 6.6 inches d.b.h. and larger having at least one log 12 feet long, and 5 inches in diameter inside bark.

TABLE 18. -- *Number of trees per acre 9.6 inches d.b.h. and larger*

Age at b.h. (years)	Number of trees by site index					
	70	80	90	100	110	120
20					21	39
30		12	52	84	117	148
40	4	65	107	126	148	165
50	24	104	133	137	146	151
60	57	124	137	132	133	134
70		132	134	126	124	124
80		132	128	119	118	117
90		127	122	114	112	
100			116	109	108	

TABLE 19. -- *Average diameter of trees 9.6 inches d.b.h. and larger*

Age at b.h. (years)	Average diameter breast high (inches) by site index					
	70	80	90	100	110	120
20					10.7	10.9
30		10.7	11.0	11.3	11.6	11.9
40	10.8	11.2	11.7	12.2	12.7	13.1
50	11.0	11.8	12.5	13.1	13.9	14.5
60	11.4	12.5	13.4	14.2	15.1	15.9
70		13.2	14.3	15.3	16.3	17.3
80		13.9	15.2	16.5	17.5	18.5
90		14.6	16.0	17.5	18.6	
100			16.8	18.4	19.6	

TABLE 20. -- *Basal area per acre in trees 9.6 inches d.b.h. and larger*

Age at b.h. (years)	Basal area (square feet) by site index					
	70	80	90	100	110	120
20					9	17
30		6	26	53	83	107
40	3	37	77	109	136	158
50	16	75	112	140	162	182
60	42	99	132	156	174	192
70		113	142	164	180	196
80		122	149	169	184	198
90		128	152	171	185	
100			154	171	186	

TABLE 21. -- *Board-foot volume per acre*[1] *to 8 inch top diameter inside bark, Scribner rule*

Age at b.h. (years)	Volume (board feet) by site index					
	70	80	90	100	110	120
20					100	1,000
30		200	1,500	3,800	7,000	11,000
40	200	2,200	6,500	10,900	16,100	22,100
50	1,100	6,400	12,000	18,000	24,700	32,100
60	3,400	10,300	16,700	24,000	32,400	41,600
70		13,800	21,100	29,700	39,700	50,300
80		16,900	25,300	35,100	46,200	57,800
90		19,800	29,200	40,000	51,900	
100			32,700	44,300	56,500	

[1] This includes all trees 9.6 inches d.b.h. and larger having at least one log 12 feet long, and 8 inches in diameter inside bark.

TABLE 22. -- *Percentage distribution of trees in and above successive diameter classes in stands of different average diameter*

Diameter class (inches)	Average diameter of stand in inches														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	58.6	84.7	94.3	98.1	99.1	99.7	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9
3	21.0	54.1	76.8	91.7	96.0	97.5	98.5	98.8	98.9	99.0	99.1	99.2	99.3	99.4	99.5
4	4.0	22.3	49.2	72.2	86.5	92.9	95.5	96.4	97.0	97.4	97.7	98.0	98.3	98.6	98.8
5	.3	8.2	25.7	47.0	68.9	82.1	88.3	92.4	93.9	95.0	95.6	96.6	97.2	97.7	98.0
6		3.5	12.3	27.5	47.1	65.9	77.6	84.8	88.3	91.1	92.7	94.6	95.9	96.7	97.0
7		1.1	6.3	15.1	29.1	46.9	63.0	73.9	80.4	85.1	88.7	92.0	94.1	95.4	95.9
8		.1	3.1	8.3	17.1	31.8	47.0	60.4	70.1	77.4	83.6	88.8	91.8	93.6	94.3
9			1.3	4.3	9.7	20.0	33.8	47.1	58.9	68.3	77.0	84.0	88.5	91.0	92.1
10			.3	2.0	5.5	12.0	23.0	35.0	47.0	58.1	68.9	77.7	83.9	87.5	89.4
11				.7	2.9	7.0	14.7	24.7	36.1	47.9	59.4	69.6	77.6	82.5	85.7
12				.1	1.4	3.8	8.7	16.4	26.9	38.0	49.1	60.0	69.4	76.5	80.5
13					.5	1.9	5.0	10.2	19.1	28.8	38.9	49.3	60.0	69.0	74.5
14						.7	2.6	6.1	13.0	21.0	29.2	38.6	49.1	60.1	67.1
15							1.2	3.7	8.3	14.7	21.2	29.0	38.6	49.8	59.0
16							.4	2.0	5.2	9.6	14.7	20.8	29.1	39.3	50.0
17								.9	3.1	6.2	9.6	14.1	21.2	30.0	41.0
18								.3	1.8	4.0	6.1	9.1	15.0	22.0	32.3
19									.9	2.3	3.8	6.0	10.0	15.6	24.7
20									.3	1.1	2.0	3.6	6.7	10.5	18.1
21										.4	1.0	2.0	4.4	7.1	12.9
22											.3	1.0	2.8	4.9	8.8
23												.4	1.7	3.1	5.9
24												.1	1.0	2.0	3.9
25													.5	1.1	2.4
26													.2	.4	1.6
27															1.0
28															.5
29															.1

TABLE 23. -- *Total volume in cubic feet**

(*PEELED WOOD*)

Diameter breast high	Total height of trees in feet													Basis (trees)
	10	20	30	40	50	60	70	80	90	100	110	120	130	
1	0.05	0.07	0.09											2
2	0.07	0.15	0.24	0.33										4
3	0.11	0.28	0.47	0.68	0.89									5
4	0.15	0.45	0.78	0.15	1.52	1.90								7
5		0.65	1.18	1.72	2.30	2.91	3.50							7
6		0.91	1.61	2.41	3.24	4.10	5.02	5.85						9
7				3.18	4.33	5.48	6.72	7.95	9.13					12
8				4.03	5.49	7.10	8.67	10.2	11.7					5
9					6.85	8.90	10.8	12.7	14.7	16.7				10
10						10.7	13.0	15.5	18.0	20.6	22.9			8
11						12.8	15.6	18.5	21.7	24.9	27.5			10
12						14.9	18.3	21.9	25.5	29.2	32.5			15
13							21.3	25.6	29.9	34.0	38.3	42.2		10
14							24.5	29.5	34.1	39.0	44.0	48.5		9
15							27.9	33.5	38.8	44.3	49.9	55.7		12
16								37.5	44.1	50.3	56.8	63.1		9
17								42.0	48.9	56.4	63.4	71.0		8
18									54.5	62.8	70.9	78.8		10
19									60.8	69.9	78.3	87.5		7
20									66.9	76.0	87.0	96.1		3
21									73.0	83.7	95.0	106		5
22									79.8	92.5	102	116		2
23									87.0	100	113	126	140	3
24									94.5	107	121	135	149	1
25										117	131	147	160	3
26										125	141	158	172	2
27										135	151	168	186	2
Basis (trees)		2	4	13	11	15	16	21	30	34	30	3	1	180

* Volume inside bark of entire stem excluding limbs.

Block indicates extent of basic data.

Values computed from the equation: $\log (V-.04) = 1.892637 \log D + 1.200620 \log (H-4.5)$

where V = Volume in cubic feet.

D = Diameter at breast height (inches).

H = Total height in feet.

Based on group averages, the coefficent of multiple correlation = .9990.

TABLE 24. -- *Cubic volume to a 4 inch top diameter inside bark**

(*PEELED WOOD*)

Diameter breast high	Total height of trees in feet										Basis (trees)
	40	50	60	70	80	90	100	110	120	130	
5	.50	.57	.67	.79							6
6	1.02	1.58	2.30	3.09	3.80						9
7	1.64	2.85	4.06	5.36	6.65	7.89					12
8		3.84	5.51	7.15	8.54	10.3					5
9		5.03	7.15	9.11	11.1	13.1	15.2				10
10			8.78	11.2	13.7	16.3	18.9	21.3			8
11			10.7	13.6	16.5	19.8	23.1	25.7			10
12			12.7	16.1	19.8	23.4	27.2	30.6			14
13				19.0	23.3	27.7	31.8	36.2	40.2		5
14				22.0	27.1	31.7	36.7	41.7	46.3		5
15				25.2	30.9	36.2	41.8	47.5	53.3		7
16					34.7	41.4	47.6	54.2	60.6		6
17					39.0	46.0	53.6	60.6	68.3		8
18						51.5	59.8	68.0	75.9		7
19						57.6	66.7	75.2	84.5		7
20						63.5	72.7	83.8	92.9		3
21						69.5	80.2	91.6	103		5
22						76.1	88.9	98.4	112		2
23						83.1	96.2	109	122	136	3
24						90.5	103	117	131	145	1
25							113	127	143	156	3
26							121	137	154	168	2
27							131	147	164	182	2
Basis (trees)	2	9	15	16	19	26	24	25	3	1	140

* Volumes include the peeled volume of the main stem to a 4 inch top inside bark, and exclude limbs.

Block indicates extent of basic data.

Values computed by subtracting from the computed values of the volume inside bark of the entire stem the volume inside bark from the tip to the 4 inch diameter inside bark as computed from the equation:

i.b. volume (4 inch i.b. to tip) = .16461062 D - .0062073 H + .63829666.

Standard error of estimate of volume i.b. (4 inch i.b. to tip) = .689425 cubic foot.

TABLE 25. -- *Board-foot volume (International 1/8 inch) rule to a 5 inch top diameter*

Diameter breast high	Total height of trees in feet									Basis (trees)
	50	60	70	80	90	100	110	120	130	
										6
7	9	12	15	18	22					12
8	16	22	28	34	41					5
9	24	32	40	50	61	72				10
10		42	54	68	83	100				8
11		55	70	88	109	129	150			10
12			86	108	133	159	185			15
13			104	131	162	193	226	259		10
14			122	156	192	229	266	305		9
15				181	223	264	308	358		12
16				205	252	298	350	410		9
17				230	282	336	396	458		8
18					317	378	443	507		10
19					350	419	486	557		6
20					379	456	525	606		3
21					410	491	570	664		5
22					445	540	610	722		2
23					480	560	660	778	894	3
24					500	600	710	836	956	1
25						650	770	890	1,020	3
26						690	805	950	1,080	2
27						730	850	1,000	1,140	2
Basis (trees)	4	13	16	21	30	33	30	3	1	151

Block indicates extent of basic data.

Values computed from the equation: $\log (V-2.85) = 1.2495 \log (D-5) + 1.6357 \log (H-4.5) - 2.0258$

where V = Volume in board feet (International log rule)

D = Diameter at breast height (inside bark) in inches

H = Total height of tree in feet.

Standard error of estimate in logarithms = .1211.

Coefficient of multiple correlation = .9845.

TABLE 26. -- *Board-foot volume, Scribner rule, to an 8 inch top diameter*

Diameter breast high	Total height of trees in feet								Basis (trees)
	60	70	80	90	100	110	120	130	
9	8	8	8	9					5
10	15	19	23	26	29	33			8
11	28	34	42	49	57	66			10
12		52	63	73	86	98			15
13		69	84	99	117	132	151		10
14		88	107	126	150	175	202		9
15		106	129	155	187	219	250		12
16			155	188	225	262	299		9
17			184	221	264	304	345		8
18			210	254	300	344	390		10
19			239	285	340	386	440		6
20				319	377	431	492		3
21				352	417	480	550		5
22				389	455	530	620		2
23				430	500	590	680	775	3
24				460	550	640	740	850	1
25					595	700	800	905	3
26					640	760	870	985	2
27					695	800	920	1,050	2
Basis (trees)	1	7	18	30	33	30	3	1	123

Block indicates extent of basic data.

Computed from the equation:

$\log.\ (V-6.67) = 1.2431 \log.\ (D-8) + 1.5465 \log (H-4.5) - 1.7886$

where V = Volume in board-feet (Scribner log rule)
D = Diameter at breast height (inside bark) in inches
H = Total height of tree in feet

Standard error of estimate in logarithms = .1387

Coefficient of multiple correlation = .9717

APPENDIX

B

TECHNIC OF GROWTH AND YIELD TABLE CONSTRUCTION

APPENDIX B

TECHNIC OF GROWTH AND YIELD TABLE CONSTRUCTION

Field Methods

The methods employed in the field work of this study were essentially those proposed in 1926 by a committee of the Society of American Foresters.[6] Basic data consist of measurements taken on 99 permanently located sample plots whose boundaries were located with a staff compass and steel tape. In general, rectangular plots were established, but where this was impracticable plots of varying shape were laid out. Acute angles were avoided. Plot sizes ranged from one-fiftieth to one-half acre, the small-sized plots having been established only in young stands where trees were small and numerous. In general,one-half acre plots were established in all stands over 50 years old. The stand-age of each plot was determined from increment cores extracted at breast height from dominant red gum trees. Throughout these yield tables, breast height age has been used instead of total age because seedlings and sprouts require different periods of time to reach breast height, and because breast height age is a more generally useful figure.

Yield plot field procedure included a careful examination of each merchantable tree (as defined on page 7). Its merchantable length was determined and divided into logs; the grade, diameter at the small end, and length of each log was estimated. From these estimates,the volume of each log was calculated by the Scribner and Doyle log rules. The aggregate merchantable volume, both total and by log grades, was computed for each plot,raised to an acre basis, and correlated with age and site. Table 1 on page 10 shows the average volumes for the various ages and sites.

Since frequent use of an Abney level maintained a satisfactory standard of accuracy in estimating heights and log lengths, the accuracy of these volume estimates depended largely upon the precision of the field mens' ocular estimates of top-of log diameters inside bark. A test of their accuracy was made through a set of taper curves constructed from volume table measurements taken on nearly 150 felled, second-growth red gum trees. Diameter estimates from these taper curves, when compared with corresponding diameter measurements on the felled trees, showed an aggregate error of -.32 percent; that is, the sum of the actual diameters was lower than the corresponding curved diameters by .32 percent. Top-of-log diameters estimated for trees on the sample plots were compared with corresponding diameters read from taper curves for trees of the given diameter at breast height. Approximately 3,670 such comparisons showed an aggregate error of -.23 percent; that is, the sum of the field estimates minus the sum of the taper curve estimates divided by the sum of the taper curve estimates equals -.0023 or -.23 percent. Individual deviations were independent of the height above the stump and of the diameter at breast height. These tests show no indication of bias or serious error in the ocular estimates.

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[6] "Methods of preparing volume and yield tables," Report of the Committee on standardization of volume and yield tables, Journal of Forestry,24: 653-666.

Method of Constructing Site-Index Curves [7]

In the construction of site index curves, it is generally assumed that the site index of a stand, as measured by the height of the average dominant tree at 50 years, is independent of the age of the stand. It is also assumed that the distribution of plots by site within an age class is independent of the age . Thus,a stand of given site index at one age will have the same site index at any other age,and the probability of the occurrence of a stand of a given site index will be the same at all ages.

The construction of site index curves necessitates relating three interdependent stand statistics, or statistics applying to groups of stands, to age. These are the height of the average dominant tree, the standard deviation of these heights around the curve of the average for an age class, and the coefficient of variation. The interdependence of these statistics is shown by the definition of the coefficient of variation. That is:

$$V = \frac{\sigma (100)}{M}$$

where

V = coefficient of variation,

σ = standard deviation of heights, and

M = curved value of height for the average site at a given age.

Hence,an independently drawn curve of the coefficient of variation over age can be compared with one derived from the curves of height and the standard deviation of heights over age and thereby provide a check on the forms of all three.

The steps followed in constructing site index curves are:

(1) Plot the height of the average dominant tree over the stand age. A curve throught these points represents the relation of height to age for the average of the site indexes.

(2) Compute the standard deviation of heights around this curve, for 10-year (or other interval) age classes, and plot aver age . A curve drawn through these points represents the trend in the variation among heights of dominant trees within an age class as the age class changes.

(3) Compute the coefficient of variation of each of these age classes, plot over age, and fit a curve to these points. This curve provides a check for curves drawn under (1) and (2).

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[7] For a more complete description of the yield and stand table construction methods used here,see "The Construction of Normal-Yield and Stand Tables for Even-Aged Timber Stands," by Osborne and Schumacher, in Journal of Agricultural Research, Vol. 51 (6): 547-564.

(4) For the reference age - 50 years - divide the deviation of each even 10-foot site index from the average site index by the curved standard deviation at 50 years to obtain the deviation in standard units of that site from the average. The deviation of each site from the curve of the average site at any given age is the product of the deviation of that site from the average in standard units at 50 years by the curved standard deviation at the given age.

(5) Derive curves for each 10-foot site index class, and from these curves assign a site index to each plot.

The distribution of plots by age and site classes is shown in the following table.

TABLE 27. -- *Distribution of plots by age and site-index class*

Breast height age class	Site-index in feet					All plots
	70-79	80-89	90-99	100-109	110-119	
(Years)	*Number of plots*					
5.0 - 15.0		2	5	3	1	11
15.1 - 25.0	1	3	1	11	1	17
25.1 - 35.0	1	1	3	6		11
35.1 - 45.0		2	4	4	1	11
45.1 - 55.0	2	2	6	7	3	20
55.1 - 65.0	2		3	6	2	13
65.1 - 75.0			3	1	1	5
75.1 - 85.0	1		3	1	1	6
85.1 - 95.0				2		2
95.1 - 105.0			2	1		3
Total	7	10	30	42	10	99

Method of Constructing Curves of Total Stand Basal Area, Number of Trees, Average Diameter, and Cubic Volume

Basal area, number of trees, and cubic foot volume per acre, as well as average diameter, were correlated with stand age and the assigned site index. For each of these four measures of yield, the first three steps outlined on page xviii were followed. As with height, the curve of each of these measures of yield for a given site deviates from the curve for the average site by a certain number of units of the standard deviation. To obtain this relationship for cubic volumes, for example, the deviation of each plot yield from the yield for the average site at the plot age was divided by the standard deviation of yield at that age. These ratios, or standard units, were then plotted over site index and a curve was fitted to the points. The deviation of the yield for any site and age from the curve of yield for the average site at that age is the product of the value read from the curve of the standard deviation at that age by the value read from the curve of standard units for that site. Through deviations computed by this procedure, for selected ages and sites, curves of yield of basal area, number of trees, and average diameter were also constructed for 10-foot intervals of site index.

Method of Construction of Partial Stand Yield Curves

Studies in fully stocked, even-aged forest stands in a given timber type have shown that stands of the same average diameter have diameter distributions that are closely alike. Therefore, the portion of the stand above a given diameter should be about the same in stands of equal average diameter, and the ratio of partial to entire stand values should be correlated with average diameter. These ratios have not been proved to be completely independent of age and site, but have been found satisfactorily so in practice.

The procedure followed in the construction of the partial stand yield curves is that of correlating the ratio of partial to entire stand values with average diameter. As an example of this procedure, the basal area of trees in and above the 7-inch diameter class was summed for all plots of the same average diameter; this sum was divided by the sum of the basal areas of all trees on the same plots, and the resultant ratios were plotted over the average diameter of these plots. A curve through these values provided a ratio corresponding to any average diameter and therefore to any age and site. The basal area in trees in and above 7-inch diameter class could then be obtained for any age and site by multiplying the total basal area by the ratio of partial to total basal area for that age and site. Curves of basal area in and above the 7-inch diameter class were constructed for each 10-foot site class. A similar procedure was followed in deriving all partial stand curves.

Method of Constructing Stand Tables

The general plan followed was that of fitting to diameter distributions of stands of the same average diameter a curve of the type

$$y = \frac{100}{1 + e^{a + bx + cx^2 + dx^3}}$$

where

y is the cumulative frequency in percent, through a diameter class,

x is the diameter breast-high in inches,

e is the base of Napierian logarithms, and

a, b, c, and d are constants calculated by the method of least squares for the average of all plots having the same average diameter.

The constants a, b, c, and d were then adjusted, and cumulative frequency curves drawn for successive inches of average diameter. By interpolation, these curves were converted to curves for stands of successive inches of average diameter, as computed from the basal area of the tree of average basal area.

Cross Check Between of Basal Area, Average Diameter, and Number of Trees

For a given plot, the total basal area equals the product of the number and the average tree basal area. Expressed algebraically, this relation is

$$B = (n\ b)$$

where B = the total basal area of a plot,

n = the number of trees on the plot,

and b = the average basal area per tree.

But $b = K\ \overline{D^2}$*

where $\overline{D^2}$ = the average of the squared diameters

K = a constant.

Because this relationship holds for an individual plot, it has been assumed that it will be true for the average of all plots within an age class. The practice of many investigators has been to derive the curve of $\sqrt{\overline{D^2}}$ (i. e., the diameter of the tree of average basal area) from the ratio of the curves of B and n. That this has been in error and has been found to be an unwarrented cross-check, is demonstrated in the following:

---

*A dash over any symbol means that it represents an average value.

For a given age class, if the average total basal area per plot equals the product of average number of trees and the average basal area of the average tree, the average of a number of cross products equals the product of the averages, or

$$\bar{B} = \bar{n}\ \bar{b}$$

for all plots within the age class.

$$B_1 = n_1\ b_1$$

$$B_2 = n_2\ b_2$$

" " "

" " "

' ' '

$$B_N = n_N\ b_N$$

$$\frac{\sum B_i}{N} = \frac{\sum n_i\ b_i}{N} \qquad i = 1, 2, \cdots N.$$

$$\text{But} \sum n_i\ b_i = \sum (n_i - \bar{n})\ (b_i - \bar{b}) + N\ \bar{n}\ \bar{b}$$

$$\text{and } \bar{B} = \frac{\sum (n_i - \bar{n})\ (b_i - \bar{b})}{N} + \bar{n}\ \bar{b} \qquad (1)$$

$$\text{or } \bar{B} = r_{nb}\,\sigma_n\,\sigma_b + \bar{n}\ \bar{b} \qquad (2),$$

From equation (2)

$$B \neq \bar{n}\ \bar{b}$$

unless either

r_{nb}, σ_n, or σ_b is zero.

This can occur only if n or b is constant or if they are uncorrelated. In all investigations, n and b have been found correlated with site. Hence, they must be correlated with each other.

In the present paper, therefore, independent curves have been drawn as the best approximations of the relationships of B, n, and $\bar{D}$ to age and site, without regard to cross-checking.

ERRATA

Appendix

Page iv - Table 8 - Read title - "Cubic-foot volume per acre of all trees 0.6 inch d.b.h. and larger."

Page iv - Table 9 - Footnote 2 - read - "average percentage," in place of "average percentages."

Page xix - Table 27 - under Breast height age class, read "5.1 - 15.0" instead of "5.0 - 15.0"

Page xx - Line 4 - read - "As with height, the curve of each of these *four* measures of yield.....".

Page xxi - Side heading in middle of page - read - "Cross Check Between *Curves* of Basal Area....", and immediately below, "For a given plot, the total basal area equals the product of the number *of trees* and the average tree basal area."

(Note: Words in italics are those omitted from original text.)

A13,27

OCCASIONAL PAPER No. 55 April 9, 1936.

SOUTHERN FOREST EXPERIMENT STATION
E. L. Demmon, Director
New Orleans, La.

THE WEED PROBLEM
AT THE
STUART FOREST NURSERY, POLLOCK, LA.

By

A.D. McKELLAR, *Junior Forester*

◆

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigations.

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THE WEED PROBLEM

AT THE

STUART FOREST NURSERY, POLLOCK, LA.

By A.D. MCKELLER, *Junior Forester,*[1]

INTRODUCTION

The purpose of this paper is to describe the weed-eradication problem at the Stuart Forest Nursery and to present data which will be useful to other nurserymen, to botanists and agronomists interested in weed species, and to investigators in chemical control of weeds.

The Stuart Nursery was established in September 1933 with a planned capacity of 10 million seedlings, which was expanded in 1935 to 50 million. Weed control at once became of major importance. During 1934 the cost of labor for weeding was $1.12 per thousand seedlings or 25 percent of the total cost of producing planting stock. The problem has been vigorously attacked by the Forest Service administrative staff, with visible progress, since the weeding cost for 1935 at the same wage rate was only 22 cents per thousand seedlings[2]. The Southern Forest Experiment Station also has undertaken studies of the weed population and of control methods.

STATEMENT OF PROBLEM

The nursery is situated about 6 miles west of Pollock, La., and 15 miles north of Alexandria. The topography is gently rolling, the nursery being located on a hill which slopes to the south. The soil is Caddo very fine sandy loam with a heavy yellow sandy clay subsoil from 4 to 10 inches beneath the surface, and is moderately acid (pH about 5.7). Its original area was 112 acres, of which a gross area of 17 acres was sowed to pine in 1934. The area occupied by the 1934 nursery had lain fallow for about 15 years after agricultural use. No green manure crops immediately preceded the pines. In 1935 the area of the nursery was increased to 140 acres, with approximately 51 acres sowed. This area was entirely cut-over pine land, except for 16 acres which were cleared in 1934 and sowed to cowpeas twice or to cowpeas once and to a mixture of *Sesbania* and Crotolaria once during 1934. The combined cost of the green manure was $15.75 per acre. Nursery practice makes it necessary to rotate crops, and while approximately 51 acres were sowed to pine seed, 27 acres were sowed at the same time to leguminous plants, which were afterwards plowed under. The remaining acreage was purposely allowed to lie fallow.

Hot, dry summers and mild to moderately cold, wet winters are characteristic of the region. The maximum surface soil temperature recorded in 1935 was 137° F. About 50 inches of rain falls annually.

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[1] Acknowledgement is made to Mr. A.D. Read, Nurseryman, for cost figures and other data, and to Dr. L.J. Pessin, Miss Anna Haas, and Dr. C.A. Brown for plant identifications.

[2] Based on fall inventory.

Longleaf and slash pines are the principal species produced. The 1935 fall inventory showed 28 million slash, 8 million longleaf, 4 million shortleaf, and 1 million loblolly pine seedlings. Seeds are sowed in February, March, and April and the seedlings lifted for planting in the field the following December, January, and February.

Seed is sowed in beds 4 feet wide and 100 feet long. The soil is first plowed, then disced several times. The beds are thrown up and each bed worked by a rototiller, a mechanical soil pulverizer. Surface raking, following deep working with long-tined "potato hooks", completes the preparation. Seed is sowed in drills on top of the soil by a mechanical seeder and pressed firmly into the ground by a heavy roller. The drills are 6 inches apart and run lengthwise of the bed. The quantity of seed sowed is computed so as to insure a stand of 12 to 15 longleaf or 8 to 20 slash, shortleaf, or loblolly per linear foot. The beds are covered with burlap mulch during germination.

At the time of lifting, when the seedlings average 10 months of age, the stems of slash pine average about 8 inches high, those of shortleaf and loblolly about 4 to 6 inches, and the needles of longleaf, which has no stem at that age, about 12 inches.

Weeds are undesirable in the forest nursery for the same reasons that they are objectionable in farm crops; they usurp soil moisture and nutrients and, if allowed to grow, seriously compete with the pines for space and light. If left, the weeds materially reduce the number of plantable trees at the end of the season (*12*)[3] and interfere mechanically with the lifting of the seedlings. Most of the weeds present are indigenous to the area. Some originate from wind-blown seed. Many of those on the 1934 site were typical of agricultural land. They probably came in as a result of previous cultivation or were introduced by fertilizing with barnyard manure during the time the land was being farmed. (See fig. 1.)

Hand weeding is the chief method of controlling weeds at the Stuart Nursery. Weeding begins in April soon after the burlap mulch is lifted and continues through October. By this time the season has passed for many weeds and the seedling crowns have closed so that few weeds come in. Each bed receives about 5 weedings at approximately monthly intervals. Data for 1935 show that the longleaf was weeded 6 times, slash 4 to 5, shortleaf 6 to 7, and loblolly 4 times. These differences are probably attributable to site and degree of infestation rather than to species of trees. The following tabulation shows the number of man-days' labor (C.C.C. enrollees) required for weeding for all species, by months, per net acre of seedlings:

Month	1934	1935
April	32	9
May	205	70
June	188	69
July	200	51
August	126	15
September	77	7
October	20	Negligible

In 1934, 1.9 man-days were required per bed and in 1935 only 0.39 man-day. This reduction in labor was due principally to the change of site from fallow soil to

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[3] Italic figures in parentheses refer to Literature Cited at end of this paper.

FIGURE 1. -- A bed of longleaf pine heavily infested with weeds, 1934.

new ground where common field weeds have not become established, but was also partly owing to greater efficiency in the work. It should be noted that the heavy weeding job falls in May, June, and July.

As an aid to hand weeding, "spuds" are used. A spud is a piece of 1/8- by 3/4-inch strap iron 6 inches long sharpened at one end and bent slightly to accommodate the thumb. The spud protects the fingers and greatly facilitates the pulling of deep-rooted plants. Benches which straddle the bed have been used to sit on when weeding, but were found cumbersome and unnecessary. Long-handled, triangular beet-hoes were used in 1935 to remove weeds between the drills of seedlings. These are practicable only where seed is drill-sowed and while the seedlings are small. The administrative staff found that, on beds where weeds were abundant, hoeing reduced the time for weeding by 40 percent in the first weeding and 7.5 percent in the second. The trees were too large after the second weeding to permit hoeing. On an area where weeds were sparse a saving in time of 8.7 percent and 13.7 percent in the first and second weedings, respectively, resulted. One disadvantage of the hoes, however, is that the bark of some seedlings is nicked, permitting attack by fungi. Hoeing and hand weeding are simpler when drills run across the bed, but this is often impractical, since most mechanical seeders sow lengthwise. In dry weather, beds are watered before weeding. Removing weeds from soft ground is easier, faster, and results in less injury to the seedlings than removing them from hard soil.

During the summer and fall months a patrol consisting of several men is maintained at the Stuart Nursery to detect and remove weeds which are going to seed in the beds. This is a very desirable practice, as it is inevitable that a few small plants are missed in the general weeding operation and these might mature before the next weeding.

Where very serious perennial weeds have been found, the soil has been dug up, pulverized, and sifted to remove underground parts of the plant. Fortunately, only a few patches of this kind have occurred and these have been immediately destroyed. Chemical control is yet in the experimental stage.

Continuous cultivation is a valuable weed-control measure. In one southern nursery the weeding cost for 1934 on beds placed on land that had been fallow for some years was 4.59 times as much as for beds on land that had been rotated with seedbeds and cover crops for several years.[4] Potato-hooking the beds, or any tillage practice that removes vegetative parts capable of regenerating the plant, is advisable. One thorough operation of this kind may save several weedings later (*12*). Deep plowing probably destroys many weed seeds, but this is not entirely effective. Some weed seeds are known to remain viable for many years when buried in the soil (*5*). Small, tender weeds are more easily destroyed than the seeds. Harrowing the soil several weeks before the date of sowing may cause the germination of weed seeds and the small plants can then be raked out at the time of bed preparation. This method is applicable, principally, where the sowing of the crop species can be postponed until after the usual time when weed seeds begin germinating.

As weed pests, grasses and forbs[5] are about equal in importance at the Stuart Nursery. The grasses grow rapidly and must be removed early to prevent disturbance of the soil. Many species, such as goosegrass, *Eleusine indica*, and *Paspalum plicatulum* spread out from the base or form dense bunches which crowd out nearby pine seedlings. Other species, such as carpet grass, *Axonopus compressus*, and Bermuda grass, *Cynodon dactylon*, creep extensively, forming thick turf. Of the grasses, the species of *Panicum*, *Paspalum*, *Andropogon*, and *Aristida* probably are most abundant. Some species are particularly difficult to eradicate because of rapid regeneration from vegetative parts. Coco-grass, *Cyperus rotundus*, Bermuda grass, and Johnson grass, *Sorghum halepense*, are of this type. Others are a nuisance because of their abundance. Some of these are *Fimbristylis geminata* (a sedge), *Aristida longespica* (three-awn), and *Polypremum procumbens* (a forb).

Some of the genera of weeds which occur at the Stuart Nursery, grouped by season of flowering, are given in the following list; the nomenclature follows Small (*8*) or Hitchcock (*3*):

Spring (March, April, May):
Diodella, Scirpus, Croton, Plantago, Cerastium, Sisyrinchium, Xanthoxalis, Ionoxalis, Hypoxis, Ranunculus, Cyperus, Serinia, Polypremum.
Summer (June, July, August):
Panicum, Paspalum, Andropogon, Eleusine, Digitaria, Axonopus, Cynodon, Fimbristylis, Diodella, Sida, Chamaecrista, Helenium, Setaria, Polypremum, Oldenlandia, Chamaesyce.
Fall (September, October, November):
Aristida, Polypremum, Oldenlandia, Chamaesyce.

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[4] Erambert, G. F., and Averell, James L. Review of Huberman's unpublished "Memorandum on conclusions and recommendations resulting from the Ozark nursery inspection trip, October 20, 1935."

[5] A forb is a non-grasslike herb.

Exact times of germination and establishment of annual weeds are not given, as many of them, particularly the grasses, cannot be identified before the flower appears. Perennial weeds are present all year. Seed dissemination may be expected generally from 3 to 6 weeks after flowering. It is advisable to attack the weeds before or atleast not later than the flowering period to prevent maturing of seed.

WEED INVESTIGATIONS

The Southern Forest Experiment Station's work upon weeds during 1935 consisted chiefly of collection and identification of plants occurring in and near the nursery, preservation of the specimens in the herbarium, determination of seasonal succession and life history of weeds, and simple experiments in chemical and mechanical control. More than 100 species of weeds have been collected, most of which occur in the beds.

For a study of life history, a portion of one bed was left unsowed and the characteristics of the weeds which came in naturally were studied. Also, weed seeds were sowed and young weeds transplanted on another plot. Interesting data may be obtained from such an area; however, it may also be a source of weed-seed infestation unless carefully watched. A bed outside the nursery probably would serve as well.

Zinc sulphate, 6.00, 8.00, and 10.00 grams per square foot; zinc chloride, 3.75, 5.00, and 6.25 grams per square foot; and sulphuric acid, 6.00, 8.00, and 10.00 grams per square foot, were tested for effectiveness in controlling weeds. The percentages of normal solutions represented by these concentrations are as follows:

Zinc sulphate	6.00 grams	13.52 percent normal
" "	8.00 "	17.94 " "
" "	10.00 "	22.34 " "
Zinc chloride	3.75 "	10.92 " "
" "	5.00 "	14.53 " "
" "	6.25 "	18.12 " "
Sulphuric acid	6.00 "	24.19 " "
" "	8.00 "	32.12 " "
" "	10.00 "	39.99 " "

Paper mulch also was tried as a mechanical means of suppressing weeds between drills.

LIST OF WEEDS OBSERVED AT STUART FOREST NURSERY

In the following list, the scientific and most of the common names of grasses have been taken from Hitchcock's manual(*3*) and names of other plants from Small's 1933 manual (*8*).The "Seed List" (*10*) of the U. S. Department of Agriculture has also been freely consulted for common names. In certain instances, departures from the Latin nomenclature of Small's flora are shown by parenthesizing such names and preceding them by the name preferred in the U.S. Department of Agriculture. For this, we have relied on a reviewer in the section of Range Forage Investigation of the Forest Service. In certain instances, also, two common names are given, the first being the preferred nomenclature indicated by the above-noted reviewer, the second, in quotation marks, being that given by Small or Hitchcock. The plants are grouped by families. The approximate flowering period also is given. Those known to be perennials are designated by (P).

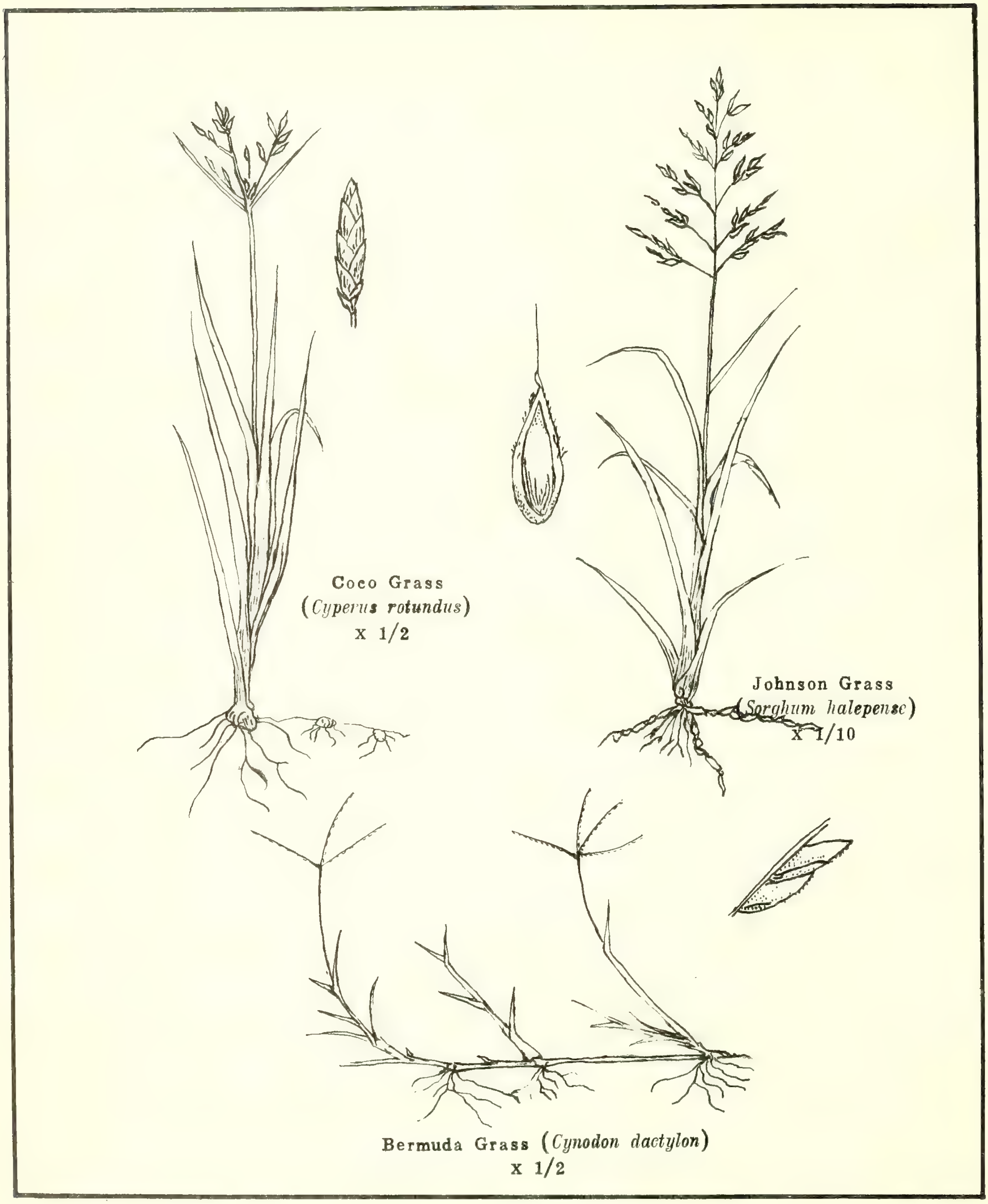

FIGURE 2. -- Three obnoxious weeds.

Alliaceae, Onion family	
Nothoscordum bivalve, false-garlic (P)	Spring
Alsinaceae, Chickweed family	
[6] *Cerastium viscosum,* sticky mouse-ear; "mouse-ear chickweed"	Spring
Ambrosiaceae, Ragweed family	
Ambrosia elatior, common ragweed; "bitterweed"	Summer
Ammiaceae, Carrot family	
Eryngium synchaetum, button-snakeroot	Summer
Brassicaceae, Mustard family	
Carara didyma, swinecress	Spring
Lepidium virginicum, peppergrass	Spring
Campanulaceae, Bellflower family	
Specularia perfoliata, Venus lookingglass	Spring
Carduaceae, Thistle family	
Chrysopsis graminifolia (*Pityopsis graminifolia*), grassleaf golden-aster	Summer
Coreopsis crassifolia, tickseed	Spring
Erigeron ramosus, wild-daisy; fleabane	Spring
Gnaphalium falcatum, cudweed	Spring-Summer
Gnaphalium spathulatum, cudweed	Spring-Summer
[6] *Helenium tenuifolium,* bitterweed	Summer
Lacinaria pycnostachya, gayfeather; "blazing-star" (P)	Summer
Lacinaria squarrosa, gayfeather; "blazing-star" (P)	Summer
Rudbeckia alismaefolia, coneflower	Summer
Solidago altissima, goldenrod	Summer
Vernonia angustifolia, ironweed (P)	Summer
Cassiaceae, Senna family	
Chamaecrista littoralis, "sensitiveplant"	Summer
Cichoriaceae, Chicory family	
Serinia oppositifolia	Spring
Convulvulaceae, Morning-glory family	
Thyella tamnifolia, "tie-vine"	Fall
Cyperaceae, Sedge family	
Carex Leavenworthii, sedge (P)	Spring-Summer
Cyperus pseudovegetus, sweetrush (P)	Spring-Summer
[6] *Cyperus rotundus,* coco-grass (P)	Summer
Fimbristylis baldwiniana, sedge	Fall
Fimbristylis castanea, sedge	Spring-Summer
[6] *Fimbristylis geminata,* sedge	Summer
Rynchospora compressa, sedge	Summer
Scirpus carinatus, bulrush	Spring-Summer
Scleria ciliata, nutrush	Spring-Summer

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[6] Particularly obnoxious or abundant species.

Droseraceae, Sundew family	
Drosera brevifolia, dwarf-sundew	Spring
Epilobiaceae, Evening-primrose family	
Ludwigia linearis, seedbox	Summer
Peniophyllum linifolium	Summer
Raimannia laciniata	Spring
Euphorbiaceae, Spurge family	
Acalypha gracilens, three-seed; "three-seeded mercury"	Summer
Chamaesyce (*strictospora?*), groundspurg (Small's 1913 manual)	Summer-Fall
Croton Engelmannii (skunkweed)	Summer
Tithymalopsis corollata, flowering spurg (P)	Summer
Fabaceae, Pea family	
Cracca angustifolia, hoary-pea (P)	Summer
Psoralea pedunculata (*Orbexilum pedunculatum*), congo-root (P)	Spring
Stylosanthes bifolia, pencilflower (P)	Spring
Trifolium procumbens, mignonette clover; "low hop-clover"	Spring
Geraniaceae, Geranium family	
Geranium carolinianum, Carolina cranesbill	Spring
Hypericaceae, St. Johnswort family	
Hypericum acutifolium, St. Johnswort	Summer
Sarothra Drummondii	Summer
Sarothra gentianoides, pineweed	Summer
Ixiaceae, Ires family	
Sisyrinchium albidum, blue-eyed-grass (P)	Summer
Sisyrinchium Brownei, blue-eyed-grass (P)	Summer
Juncaceae, Rush family	
Juncus dichotomus, rush	Spring
Juncus marginatus, rush	Summer
Juncus robustus, rush	Summer
Juncus tenuis, hemprush	Summer
Lamiaceae, Mint family	
Hedeoma hispida, rough pennyroyal; "mock pennyroyal" (Small's 1913 manual)	Summer
Salvia lyrata, lyre-leaf sage	Spring
Scutellaria integrifolia, skullcap	Summer
Leucojaceae, Amaryllis family	
[6] *Hypoxis hirsuta,* stargrass	Spring
Lobeliaceae, Lobelia family	
Lobelia leptostachys, lobelia	Summer

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[6] Particularly obnoxious or abundant species.

Malvaceae, Mallow family	
Modiola caroliniana, "cheese plant"	Spring
[6] *Sida rhombifolia*	Summer
Melastomaceae, Meadowbeauty family	
Rhexia mariana, pale meadowbeauty (P)	Summer
Mimosaceae, Mimosa family	
Leptoglottis Nuttallii, sensitivebriar (P)	Summer
Orchidaceae, Orchid family	
Limodorum multiflorum, grass-pink	Spring
Oxalidaceae, Woodsorrel family	
Oxalis macrantha (*Xanthoxalis macrantha*), yellow woodsorrel	Spring
Oxalis stricta (*Xanthoxalis stricta*), common yellow woodsorrel	Spring
Oxalis violacea (*Ionoxalis violacea*), violet woodsorrel	Spring
Plantaginaceae, Plantain family	
[6] *Plantago aristata,* bottlebrush plantain	Summer
[6] *Plantago heterophylla,* plantain	Spring-Summer
[6] *Plantago virginica,* paleseed plantain	Spring-Summer
Poaceae, Grass family	
Agrostis hiemalis, ticklegrass	Summer
[6] *Andropogon virginicus,* broomsedge (P)	Summer-Fall
[6] *Aristida longespica,* three-awn	Summer-Fall
[6] *Axonopus compressus,* carpet grass	Summer
Brachiaria extensa	Summer
[6] *Cynodon dactylon,* Bermuda grass (P)	Summer
[6] *Digitaria sanguinalis,* crabgrass	Summer
[6] *Digitaria violascens*	Summer
[6] *Eleusine indica,* goosegrass	Summer
Hordeum pusillum, little barley	Summer
Panicum anceps	Summer
[6] *Panicum angustifolium*	Summer
[6] *Panicum lanuginosum*	Summer
[6] *Paspalum dilatatum,* Dallis grass (P)	Summer
Paspalum floridanum, * Florida paspalum (P)	Summer
[6] *Paspalum plicatulum,* * Savannah paspalum (P)	Summer
[6] *Paspalum supinum,* * longleaf paspalum (P)	Summer
Poa annua, annual bluegrass	Summer
[6] *Setaria lutescens,* yellow bristlegrass	Summer
[6] *Sorghum halepense,* Johnson grass (P)	Summer
Triodia stricta, * longspike triodia	Summer
Polygalaceae, Milkwort family	
Polygala Curtissii, Curtiss polygala; "button-rosy"	Summer

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[6] Particularly obnoxious or abundant species.

* Name not in (*3*); supplied by Div. Range Forage Investigation, Forest Service.

Polygonaceae, Buckwheat family	
Persicaria hydropiperoides, smartweed; "mild waterpepper"	Summer
Ranunculaceae, Crowfoot family	
[6] *Ranunculus fascicularis*, early wood buttercup	Spring
Rhinanthaceae, Figwort family	
Agalinis aphylla, agalinis; "gerardia"	Fall
Linaria canadensis, blue toadflax	Spring
Rubiaceae, Madder family	
Diodia teres (*Diodella teres*), buttonweed	Summer-Fall
Diodia tetragona, buttonweed (P)	Summer
[6] *Houstonia pusilla*, bluet	Spring
[6] *Oldenlandia Boscii*, (P)	Summer-Fall
Richardia scabra, Mexican-clover	Fall
Solonaceae, Potato family	
Physalis virginiana, groundcherry	Summer
Spigeliaceae, Logania family	
Polypremum procumbens	Fall
Tetragoniaceae, Carpetweed family	
Mollugo verticillata, carpetweed	Spring-Fall
Verbenaceae Vervain family	
Verbena Halei, verbena	Spring
Violaceae, Violet family	
Viola primulifolia, running violet; * (white violet)	Spring

The above is a partial list only. Some species occurring at the Nursery have not yet been collected. All species were identified by the writer, and his identification was checked by Miss Anna Haas at the Southern Station, and by Professor Clare A. Brown at the Botany Department of Louisiana State University. Specimens are preserved in the herbarium of the Southern Forest Experiment Station in New Orleans, and duplicates are preserved at the Stuart Nursery and in the herbarium of the Botany Department of Louisiana State University, Baton Rouge, La.

Brief descriptions of several important weeds found at the Stuart Nursery follow: The three following species are important because they are particularly obnoxious and difficult to eradicate.

(1) *Cyperus rotundus*, coco-grass, is a perennial sedge 8 to 24 inches tall with a tuberous rootstock. The inflorescence is a cluster of purplish brown spikelets about 1/4-inch to 1 inch long. The tubers or "nuts" on the roots increase rapidly in number and are very persistent. These must be eradicated and the fruit prevented from maturing.

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* Local common name, not given by Small.

[6] Particularly obnoxious or abundant species.

(2) *Sorghum halepense,* Johnson grass, is a perennial grass 18 to 60 inches tall with a stout, creeping rootstock. The inflorescence is an open panicle with spikelets about 3/8-inch long, bearing deciduous short awns. This plant has been known to produce hydrocyanic acid in sufficient amounts to poison grazing animals.

(3) *Cynodon dactylon,* Bermuda grass, is a common perennial lawn grass 4 to 16 inches high with extensively creeping stolons and rootstocks. The spikelets are about 1/16-inch long on 4 to 5 digitate spikes 3/4-inch to 2 inches long. The leaves are narrow.

The following three species are important because of their great abundance.

(1) *Fimbristylis geminata* is an annual sedge 2 to 8 inches high with reddish brown, umbelled spikelets 1/16- to 3/16-inch long. It is shallow-rooted.

(2) *Aristida longespica,* three-awn, is a slender-stemmed annual grass 6 to 20 inches high with awned spikelets in an appressed panicle. It is abundant in late summer and fall. Its narrow leaves are difficult to distinguish in longleaf pine beds.

(3) *Polypremum procumbens* is a small, diffusely branching forb with linear leaves about 1/2-inch long and white tubular flowers 3/16-inch in diameter. Branches are 4 to 12 inches long. This plant forms dense mats in the bed.

EXPERIMENTS IN WEED CONTROL

Chemical treatment

In 1934 sixteen 4- by 4-foot plots sowed to longleaf pine were treated with zinc sulphate to test its effect on weeds and pine seedlings. It was applied 24 hours before sowing the seed, at the rates of 6.00, 8.00, 10.00, and 12.00 grams per square foot in 3 gallons of water per plot. Treatments and the check were replicated four times. Zinc sulphate effectively controlled the forbs but did not control the grasses. Pine germination was slightly lower in the treated plots than in the checks, but the chemical did not retard the growth of the pine seedlings. (See Fig. 3)

In 1935 the following treatments were tried: (See p. 5)

Zinc sulphate, 6.00, 8.00, and 10.00 grams per square foot.

Zinc chloride, 3.75, 5.00, and 6.25 grams per square foot (zinc content equivalent to that in zinc sulphate).

Sulphuric acid, 6.00, 8.00, and 10.00 grams per square foot.

Each treatment was replicated four times, once in each of four blocks. The treatments were randomized in each block. The chemicals were applied 24 hours before sowing, in 500 cc. of water per square foot. The plots were 1 by 2 feet, boxed in by a bottomless wood frame 10 inches deep, the top of which was at ground level. Several days before sowing, the top 2 inches of soil in these plots was removed and steamed for one hour to kill weed seeds already present. One half of each plot was drill-sowed to longleaf and one half to slash pine. One hundred seeds of each of

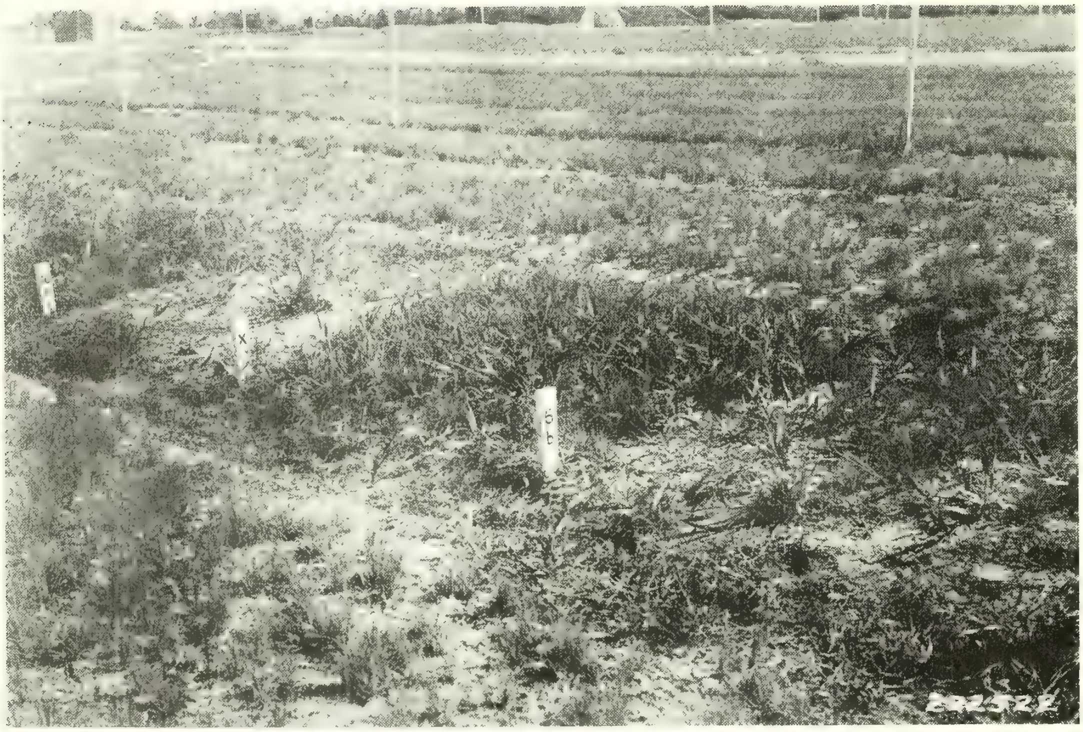

FIGURE 3. -- A portion of a longleaf pine bed in 1934 showing plot 6b treated with 6 grams of zinc sulphate per square foot, plot 10b treated with 10 grams of zinc sulphate per square foot, and a check plot (x) between. Note the number of weeds in the check as compared to the treated areas.

three species of weeds, *Polypremum procumbens*, *Sida rhombifolia*, and *Hypericum acutifolium*, were broadcast on each square foot. These are forbs. No grasses were used because the seed was not available. Two blocks of plots were used for germination counts of pine and weed seeds. These were covered with half-inch mesh wire screen and two layers of cheesecloth to prevent the entrance of additional weed seed. The other two blocks were used to study survival of weeds and pine. All plots were covered with burlap mulch after sowing.

Results show that weed seeds germinate in the presence of these chemicals. The average[7] number germinated per square foot, by treatments and species, is shown in table 1.

---

[7] Average of plots in germination study blocks. Data as of December 12, 1935.

TABLE 1. -- *Average number of seed germinated per square foot, by treatments and species*[1]

Treatment	*Sida rhombifolia*	*Polypremum procumbens*	*Hypericum acutifolium*	Unsowed	
				Grasses	Other
Zinc sulphate					
6 grams	43	72	10	9	5
8 grams	48	64	10	5	5
10 grams	40	53	2	8	0
Zinc chloride					
3.75 grams	35	60	2	7	2
5.00 grams	50	69	5	6	1
6.25 grams	36	62	0	2	1
Sulphuric acid					
6 grams	57	57	12	25	11
8 grams	50	70	21	12	10
10 grams	54	38	15	23	9
Check	56	66	10	22	21

[1] Since 100 seeds of each species were sown on each square foot, these figures are equivalent to germination percent.

All concentrations of zinc sulphate and zinc chloride were effective in killing forbs after germination. Present indications are that one application per year is sufficient. Sulphuric acid in the concentrations used was not effective. Weed survival is shown in table 2.

TABLE 2. -- *Weed survival, by treatment*

Date	Weeds per square foot [1]																		
	Chemical	Zinc sulphate						Zinc chloride						Sulphuric acid						Check	
	Grams	6.00		8.00		10.00		3.75		5.00		6.25		6.00		8.00		10.00			
	Weeds	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses	Forbs	Grasses
May 1, 1935		31	1	30	1	37	0	34	1	25	0	25	0	40	1	36	1	36	0	60	1
May 7, 1935		38	0	42	0	53	0	47	0	36	0	42	0	47	1	44	1	43	0	88	1
May 13, 1935		12	1	12	1	12	1	20	1	11	0	1	0	31	2	25	1	18	2	48	1
May 21, 1935		1	1	0	1	3	0	1	1	1	0	0	0	30	2	23	2	20	3	24	2
May 27, 1935		1	1	1	1	1	0	0	1	1	0	0	0	30	3	28	2	17	4	20	3
June 10, 1935		1	0	1	0	0	0	0	1	0	0	0	0	29	4	28	2	17	5	22	2
July 9, 1935		0	1	0	0	0	0	0	1	1	0	0	0	28	5	26	2	16	5	20	3
August 10, 1935 [2]		0	1	0	1	0	0	0	1	1	0	0	0	24	2	22	2	14	3	23	2
September 13, 1935		0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	1	0	2	0
October 11, 1935		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
November 18, 1935		0	3	0	2	0	2	0	3	0	2	0	1	0	1	0	1	0	2	0	2
December 12, 1935		7	2	6	2	7	2	13	4	5	2	5	1	1	0	6	2	8	2	7	2

---

[1] Average of 2 plots in survival study blocks. The forbs include a few weeds of unsowed species.

[2] All weeds were removed from the plots August 10, 1935, to release pine seedlings.

The total germination of slash pine[8] was not affected by the chemicals.

Table 3 shows the total germination, by treatments.

TABLE 3. -- *Total germination of slash pine per square foot, by treatments*[1]

	Zinc sulphate			Zinc chloride			Sulphuric acid			Check[2]
Grams	6.00[2]	8.00[2]	10.00	3.75	5.00	6.25	6.00	8.00	10.00	
Total germination	57	-	65	65	62	65	66	66	73	72

[1] Since 100 seeds were sowed on each square foot these figures are equivalent to germination percent. They represent the average of two plots in the germination study blocks.

[2] Because of errors in seed count the figure for zinc sulphate 8 grams is omitted and those of zinc sulphate 6 grams and the check are based on one plot only; other figures are based on two plots.

Final survival of slash pine was consistently high except for the zinc chloride 6.25 gram treatment. The pine surviving December 12, 1935, is shown in table 4.

TABLE 4. -- *Survival of slash pine by treatments*[1]

	Zinc sulphate			Zinc chloride			Suphuric acid			Check
Grams	6.00	8.00	10.00	3.75	5.00	6.25	6.00	8.00	10.00	
Survival	62	60	76	93	53	25	75	79	56	57

[1] These figures represent the percentages of the germinated and established seedlings which survived as of December 12, 1935.

The final averages of stem height, stem diameter, and root length of the slash pine seedlings are shown in table 5. There appears to be no serious detrimental effect on these factors from the use of the chemicals. The roots of the treated seedlings were fibrous and spreading and compared favorably with the check. All the plots were sowed late in the season and therefore the best development was not obtained in either the treated or the check plots. The presence of the weeds may have retarded the development of the seedlings.

---

[8] Longleaf pine was not considered because of low germination caused by poor seed.

TABLE 5. -- *Final measurements of slash pine*[1]

Treatment	Stem length[2]	Stem diameter[2]	Root length[2]
	Centimeters		
Zinc sulphate			
6 grams	8.6	.23	8.2
8 grams	10.3	.36	8.9
10 grams	8.6	.21	8.3
Zinc chloride			
3.75 grams	10.3	.23	11.5
5.00 grams	9.4	.24	10.8
6.25 grams	9.7	.31	14.1
Sulphuric acid			
6 grams	10.0	.23	9.9
8 grams	10.0	.22	9.0
10 grams	9.9	.26	8.4
Check	10.8	.30	10.2

[1] Seedlings lifted and measured December 12, 1935.

[2] Arithmetic averages.

The rapidity of germination of the pines was slightly reduced by all concentrations of zinc sulphate, zinc chloride, and sulphuric acid, except the 10 grams zinc sulphate treatment, which slightly increased the speed of germination.

As a check on the effectiveness of the steaming for sterilization, one additional plot in each block was left unsteamed and sowed to pine but not to weed seed. These were not chemically treated. Weeds other than those sowed appeared in the steamed plots about as abundantly as in the unsterilized plots, indicating that steaming for one hour is not effective. It is believed that the germinated seeds were initially present in the top soil rather than passing through the screen or germinating below the 2-inch soil level. Most of these were grasses.

These experiments confirm previous tests (*12*) at Bogalusa in 1924, 1925, 1926, and 1928, and at the Stuart Nursery in 1934, in which it was found that zinc sulphate was effective in controlling forbs but failed in the case of grasses. Experiments in England (*9*) also showed that zinc sulphate applied to soil used as a seed cover controlled weeds.

Many chemicals other than those listed have been used with varying success to control weeds. The object usually has been to destroy all vegetation, as along roadsides or around buildings. It is easier to accomplish this than to find chemicals which are selective in their action; i.e., which kill weeds without injury to crop plants. Chemicals, usually applied as sprays, are either corrosive in nature or actually poisonous upon penetrating the leaves, stems, or roots. Some weed killers in common use but not tried at the Stuart Nursery are given below:

a. Iron sulphate, 2 pounds per gallon of water.

b. Sodium arsenite, 1 to 5 pounds per 25 gallons of water.

c. Common salt, 3 pounds per gallon of water.

d. Dowicide-H, 10.8 ounces to 12 square feet of bed.

e. Sodium chlorate, 1 to 1.5 pounds per gallon of water.

f. Gasoline, full strength.

g. Kerosene, full strength.

h. Crude oil, full strength.

Extreme care should be exercised in using sodium chlorate, which is very imflammable, and sodium arsenite, which is poisonous. Dowicide-H is a commercial lumber dip.

Paper mulch

In 1935 an attempt was made to control weeds by covering the soil between drills with strips of black mulch paper. The paper was held down tightly by wire pins. Check plots were left without the mulch. In the mulched plots, weeds came up between the seedlings in the drills, which, of course, could not be covered by the paper. Comparison of time required for periodic hand weeding revealed little difference between treated and check plots. A slight advantage of the mulched plots in the spring was offset by a disadvantage in the fall. In view of the cost and time required to lay the paper, mulching cannot be justified.

These results are confirmed by experiments conducted by the Southern Forest Experiment Station at Bogalusa, La., and Camp Pinchot, Fla., and by the Great Southern Lumber Company at Bogalusa, in which it was found that "...the nature of the crop to be grown is such that 20 to 30 percent of the soil must be exposed as contrasted with perhaps 5 to 10 percent in the case of such crops as eggplants, tomatoes, and beans. The exposure of so much soil gives the weeds plenty of chance to come up among the crop plants, and thus one of the principal advantages of the paper mulch is lost"(*12*). A point of interest, however, is that, at the Stuart Nursery, the seedlings in the mulched plots had a greener color than those in the unmulched.

Relation between method of sowing and time required for weeding

An experiment conducted by the administrative staff relative to time required to weed beds sowed in drills lengthwise of the bed, in drills crosswise, and sowed broadcast showed a slight advantage for the cross-drills. The lengthwise-drilled beds required as long to weed as the broadcast-sowed. Hoes were used on the drill-sowed beds whenever greater efficiency could be obtained by doing so. Broadcast beds were hand weeded only.

SUMMARY AND CONCLUSIONS

1. Weed eradication is one of the major problems at the Stuart Forest Nursery, near Pollock, La.

2. Weeding costs in 1934 were $1.12 per thousand seedlings; in 1935 they were 22 cents per thousand. The chief cause of the high cost in 1934 was the use of an old-field site already infested with weeds. The 1935 area was new ground, cleared from forest.

3. Hand weeding is the principal method of controlling weeds at the Stuart Nursery. From 4 to 7 weedings are required per year, varying with the site and degree of infestation. A small hand tool called a spud is used to advantage. Benches to sit on were tried but were discarded. Long-handled, triangular beet-hoes used to remove weeds between drills of seedlings were found to be practicable in early weedings. Where weeds were numerous the hoes saved as much as 40 percent in time. They cannot be used after the seedlings become large, as some injury results from nicking the bark and through the wounds thus made fungi enter to attack the trees. A patrol is maintained during the summer and fall months for locating and removing weeds which are going to seed in the beds. Where very serious perennial weeds, such as coco-grass, have been found, the soil has been dug up, pulverized, and sifted to remove underground parts. Chemical weeding is yet in the experimental stage.

4. The heavy weeding job falls in May, June, and July.

5. Continuous cultivation is a valuable weed-control measure. In one southern nursery the weeding cost for 1934, on beds placed on land that had been fallow for some years, was more than 4½ times as great as for beds on land that had been rotated with seedbeds and cover crops for several years. Deep plowing, although it probably destroys many weed seeds, is not entirely effective. Some weed seeds are known to remain viable for many years when buried in the soil.

6. As weed pests, grasses and forbs are about equal in importance at the Stuart Nursery. Some species, such as coco-grass, Johnson grass, and Bermuda grass, are particularly difficult to eradicate. Other species, such as *Fimbristylis geminata, Aristida longespica,* and *Polypremum procumbens* are a nuisance because of their abundance.

7. Some of the more important genera of weeds which occur at the Stuart Nursery are listed on page 4.

8. The Southern Forest Experiment Station's work upon weeds during 1935 has consisted chiefly of collection and identification of plants in and near the nursery, preservation of the specimens in the herbarium, determination of seasonal succession and life history of weeds, and simple experiments in chemical and mechanical control. More than 100 species of weeds have been collected, most of which occur in the beds. A list of weeds at the Stuart Nursery is included in this paper and brief descriptions of several important weeds are given.

9. Zinc sulphate at the rate of 6.00, 8.00, and 10.00 grams per square foot; zinc chloride, 3.75, 5.00, and 6.25 grams; and sulphuric acid, 6.00, 8.00, and 10.00 grams, were applied to plots 24 hours before sowing to test the effect of these chemicals on pine germination, survival, and growth, and on weed germination and survival. Three species of forbs were sowed in the plots. No grasses were sowed but the effect of the chemicals on the grass seedlings which came in naturally was studied. The top 2 inches of soil was steamed for 1 hour to kill weed seeds already present. The following conclusions were drawn from the experiment:

a. Weeds germinate in the presence of these chemicals in the concentrations used.

b. All concentrations of zinc sulphate and zinc chloride are effective in killing forbs after germination.

c. Sulphuric acid was not effective in killing weeds.

d. The total germination of slash pine was not affected by the chemicals. The rapidity of germination was slighty increased by preapplication of zinc sulphate, 10 grams per square foot, but slightly decreased by all other treatments.

e. The final survival of slash pine was high for all treatments except the zinc chloride, 10 grams, application.

f. Averages of stem height, stem diameter, root length, and root development of treated seedlings compared favorably with those of the untreated check.

g. Steaming the soil for 1 hour was not sufficient to kill all weed seeds.

10. Paper mulch was tried as a weed-control method. No reduction in weeds or weeding time resulted. In view of the cost and time required to lay the paper, mulching cannot be justified. The pine seedlings in the mulched plots had a greener color, however, than those in the check plots.

11. There was very little difference in time required to weed beds where the seeds were sowed in drills lengthwise of the bed, crosswise of the bed, and sowed broadcast. The slight difference shown was in favor of the cross-drilled beds.

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LAND OWNERSHIP IN SURVEY UNIT #1

FLORIDA - 1934

By

Ronald B. Craig

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This paper releases data gathered in current investigations at th
ern Forest Experiment Station, and is subject to correction o
cation following further investigation.

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LAND OWNERSHIP IN SURVEY UNIT #1

FLORIDA - 1934

INTRODUCTION

In any study aimed to devise a land-use policy for a given economic region it is necessary to know, among other factors, who owns the land and in what size tracts it is held. Other factors, which will not be discussed here, include the costs as represented by taxes, and the stability of ownership, the relation of these factors to local public finance, and the costs of government. To answer the first two of these questions for the area embraced in the northeastern section of Florida, the data in this preliminary progress report were obtained by analysis of county tax-rolls in eight selected counties as of June 1, 1934. Subsequent papers in this series will deal with taxation, tax delinquency, and related matters, and the relation of all these factors to land-use and economic development.

The eight counties studied were Alachua, Columbia, Dixie, Madison, Nassau, St. Johns, Suwannee, and Volusia. In each county a two-man crew abstracted the data on land ownership from the tax-roll, the information on the chief business or occupation of property-owners being obtained from the county officials or other informed persons at the county-seat. Owing to wide variations in completeness, accuracy, and form among the records in these counties, these data cannot be regarded as absolutely accurate and final, but are sufficiently correct to indicate trends and major differences in ownership conditions in the several counties. It cannot properly be assumed that the data for any one county or group of counties can be applied to other counties not studied to obtain an average for the Unit, since local conditions vary considerably among the 21 counties.

LOCATION AND DESCRIPTION OF UNIT [1]

Location

Florida Unit #1, the section of the State included in this study, comprises the twenty-one counties of northeastern Florida lying between the Atlantic Ocean on the east, the Gulf of Mexico and the Aucilla River on the west, the Florida-Georgia state line on the north, and the southern boundaries of Volusia, Marion, and Levy Counties on the south. (See Fig. 1.)

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[1] Data obtained by the Forest Survey of the South, an activity of the Southern Station, which bases its field work and reports on units of 4,000,000 to 10,000,000 acres, each unit being generally homogeneous in regard to physical and forest conditions and forest types.

Area

The gross land area of the Unit as reported by the U. S. Census of 1930 is 9,778,560 acres (3) [2]. The area on the tax-rolls of the eight sample counties carried as rural land (area reported by public land survey subdivisions rather than in urban lots and blocks) is 3,169,148 acres as compared with a gross land area of 3,990,400 acres. The difference, or 820,000 acres, includes the area taken up by cities, towns, and villages, road and railroad rights-of-way, waterways, and in platted subdivisions which have not been restored to the "acreage" roll following abandonment as subdivisions after the collapse of the "boom" of 1924-1926.

Land-Use

More than three-fourths of the total land area of the Unit is forest land, 15 percent is agricultural land, and the balance is marsh and prairie, or in towns, rights-of way, or waterways. Not including the 263,000 acres of the Ocala National Forest, (See Fig. 1) there are 7,378,900 acres of forest-land in the Unit. (2). This forest area is composed of three major types of timber, in several conditions of growth and stocking, as shown in Table 1. (2).

Resources

The agricultural products of the Unit vary, of course, in the different sections. For the Unit as a whole, the principal agricultural crops, in order of value of product in 1929, were as follows: vegetables (truck), citrus and small fruits, cotton, corn and small grains, and other field crops. This Unit exceeds, except for citrus fruits, any other section of the State in value of the agricultural crops produced, the total value in 1929 being $19,840,681. Compared with other states, Florida, except for its fruit, ranks relatively low in agricultural crop production. (4).

In value of forest resources, this Unit also exceeds any other section of the state. Its chief products are naval stores, lumber, poles and piling, and crate and box material. Total naval stores production in the 1933-1934 season was 81,610 units,[3] from 1,381,300 acres. Seventy-six percent of this working acreage was leased and the remainder owner-operated. (1).

The total present board-foot volume of saw-timber (International Rule) is estimated by the Forest Survey at 10,680,100 M feet, of which 6,017,100 M feet is pine, 2,645,100 M feet hardwood, and 2,017,900 M feet cypress. (From unpublished data.)

The Forest Survey also estimates that the volume of pulping material in the forest, exclusive of round, working, and idle turpentine pines, but including trees worked out for turpentine, is 14,525,000 cords. This figure includes the cordwood volume in sawlogs, poles, piling, etc., and is not the volume avail able exclusively for pulpwood. (2). In 1929 this unit produced 60 percent of the total value of farm woodland products in the entire state.

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[2] Figures in parentheses refer to literature cited at end of report.

[3] A naval-stores unit consists of one 50-gallon barrel of turpentine and 3-1/3 500-pound (gross) barrels of rosin.

Table 1. - Forest area by forest conditions and forest type groups, Survey Unit #1 [1] Florida

Forest conditions	Forest type groups: Longleaf and slash pine predominating	Forest type groups: Loblolly and other nonturpentine pine predominating	Forest type groups: Hardwood predominating	Total	Proportion of total forest area
	Acres	Acres	Acres	Acres	Percent
Old-growth uncut	174,200	77,300	385,600	637,100	8.6
Old-growth partly-cut	429,700	49,600	391,100	870,400	11.8
Second-growth saw-log size uncut	1,183,400	191,600	138,000	1,513,000	20.5
Second-growth saw-log size partly-cut	91,400	39,400	15,800	146,600	2.0
Second-growth under saw-log size uncut	1,816,600	146,600	675,700	2,638,900	35.8
Second-growth under saw-log size partly-cut	33,000	2,400	15,800	51,200	.7
Clear-cut [2]	1,001,400	33,200	32,200	1,066,800	14.4
Reproduction	217,700	44,900	111,100	373,700	5.1
Subtotal	4,947,400	585,000	1,765,300	7,297,700	98.9
Noncommodity [3]				81,200	1.1
Total				7,378,900	100.0
Percentage of total forest area	67.1	7.9	23.9		

---

[1] Excludes the Ocala National Forest, but includes the Osceola National Forest.

[2] The area shown in the clear-cut condition includes a relatively small area in the fire-killed condition.

[3] Forest areas that do not bear commercial timber species; therefore not included in the three major type groups.

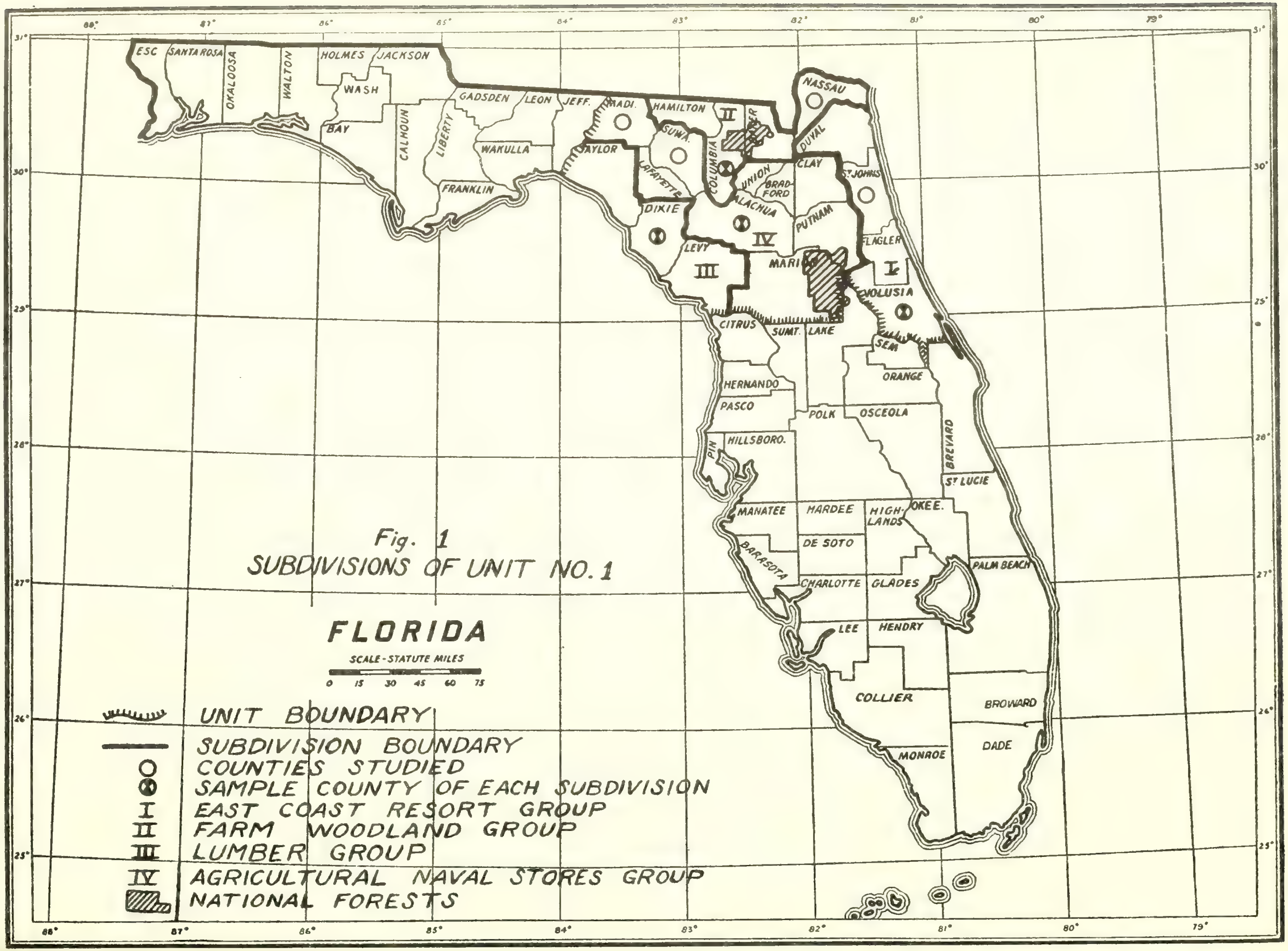

Fig. 1
SUBDIVISIONS OF UNIT NO. 1

Population

The total estimated population of the Unit, as of January 1, 1932, was 453,774, or 30 percent of that of the entire state. (6). The population was distributed according to the Census of 1930 (5) as follows: urban - 48 percent, rural non-farm - 30 percent, rural farm - 22 percent. The urban population is concentrated chiefly in larger towns and cities on or near the East Coast (Jacksonville, St. Augustine, Daytona Beach, Palatka, Deland) and in a few inland towns (Lake City, Gainesville, Ocala, Madison, Perry). As indicated, less than one-fourth of the population is classed as farmers.

The negro population, comprising 37 percent of the total, is evenly distributed throughout the Unit.

Occupationally, 22.5 percent of those 10 years old and older gainfully employed (total - 177,334 persons) were engaged in agriculture, 10 percent in forest industries and woods work, 12 percent in the "resort" business, 10 percent in wholesale and retail trade, and 46 percent in other occupations, chiefly building trades, tobacco factories, domestic, professional, and personal services. (5).

Physio-Economic Subdivisions of Unit #1.

The Unit can be divided into four divisions showing more or less distinctive physical and economic conditions. (See Fig. 1). These are as follows: East Coast "Resort" Counties (Duval, Flagler, St. Johns, Volusia); Farm Woodland Counties (Baker, Columbia, Hamilton, Nassau); Lumber Counties (Dixie, Levy, Taylor); and Agricultural-Naval Stores Counties (10 remaining counties). While the physical and economic conditions of these groups overlap to some extent, there are sufficient differences between any two groups to warrant separate classification. A summary of the character of the population and of the principal products of each subdivision is given in Table 2.

To simplify the presentation of detailed ownership data, one county from each of these four groups has been chosen as representative of its group. Volusia County is the sample from the East Coast "Resort" counties, Columbia from the Farm Woodland, Dixie from the Lumber, and Alachua from the Agricultural-Naval Stores counties. Only briefed data will be presented from the other four counties studied (St. Johns, Nassau, Suwannee, Madison; see Fig.1).

LAND OWNERSHIP

East Coast Resort Group

In at least three of the four East Coast Counties, resort business is one of the principal activities. It is concentrated to a considerable degree on a narrow strip of land from two to ten miles wide bordering the Atlantic Ocean, and to a lesser degree along the St. Johns River on their western boundaries. In St. Johns and Flagler Counties much of the remaining area is undeveloped. Duval County, containing the cities of Jacksonville and South Jacksonville, is largely urban in character. Volusia County, with the cities of Daytona Beach, DeLand, and 13 smaller towns, also has a large urban population. Other data of interest concerning this group are shown in Table 2.

Volusia County is generally representative of conditions in this group. Detailed data on its land ownership conditions are presented in Table 3 and Figure 2.

Table 2. - Character of Population, Nature of Products in Physio-Economic Subdivisions of Unit #1, Florida

Physio-Economic group	Gross area (acres)[1]	Total population[2] 1930	Distribution of population[2]					Principal crops	
			Urban	Rural non-farm	Rural farm	Colored	White	Agricultural[3]	Forest
			Percent						
East Coast	1,922,560	219,402	79.0	16.3	4.7	33.5	66.5	Vegetables, fruits, nursery prod.	Lumber, crate and box material, posts.
Farm Woodland	1,627,520	32,011	8.6	66.1	25.3	39.8	60.2	Cotton, corn hay, nursery products.	Lumber, naval stores, cooperage.
Lumber	1,857,920	39,740	18.7	38.9	42.4	38.3	61.7	Vegetables, corn, and other grain.	Lumber, poles, piling, naval stores.
Agrl.-Naval Stores	4,370,560	145,574	18.5	39.1	42.4	41.3	58.7	Vegetables, fruit, corn cotton.	Naval stores, crate and box material, cooperage, lumber.
Whole Unit	9,778,560	436,737	48.2	29.6	22.2	37.0	63.0	Vegetables, fruit, corn, & small grains, cotton, hay.	Naval stores, lumber, cooperage, crate & box material, poles.

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[1] Data from: U. S. Bureau of Census, 15th Census of U. S. - 1930. Agriculture, 1st Series, Florida.
[2] Data from: Ibid. - Population Bull. - 2nd Series - Florida.
[3] Data from: Ibid. - Agriculture - 2nd Series - Florida.

Table 3. - Distribution of Land Ownership by Types of Owners and Size-class of Holdings - Volusia County, Florida - 1934

Type of Owner	Total Owners Per Type		Total Area Per Type	
	Number	Percent	Acres	Percent
Farmers	578	25.3	33,164	9.7
Land Speculators	83	3.6	141,608	41.1
Townspeople	28	1.2	23,928	6.9
Bank, Loan, Ins., and Util. Co.	16	0.7	3.436	1.0
Lumbermen	8	0.4	51,804	15.0
Naval Stores Oper.	5	0.2	1.650	0.4
Public	3	0.1	17,452	5.1
Non-classified non-residents	1,531	67.1	70,931	20.6
Unknown	32	1.4	637	0.2
Total	[1]2,284	100.0	[2]344,610	100.0

Size-Class of Holdings	Total Holdings Per Class		Total Area Per Class	
Acres	Number	Percent	Acres	Percent
1 - 50	1,825	77.5	27,501	8.0
51 - 100	307	13.0	25,556	7.4
101 - 500	143	6.2	30,040	8.7
501 - 1000	43	1.8	29,230	8.5
1001 - 2000	15	0.6	21,945	6.4
2001 - 5000	7	0.3	19,245	5.6
5001 - 10,000	9	0.4	65,550	19.0
Over 10,000	4	0.2	125,543	36.4
Total	[1]2,353	100.0	[2]344,610	100.0

1/ Total number of owners and total number of holdings differ because in one classification only three public owners are listed (federal, state, municipal) while in the other classification, public areas are listed by number of separate holdings per size-class.

2/ Rural land on tax-roll, exclusive of areas within incorporated towns, rights-of-way, waterways, etc. About 350,000 acres of Volusia County are listed as in blocks and lots, the "boom" incorporations never having been unincorporated. Above areas include rural land theoretically forfeited for non-payment of taxes.

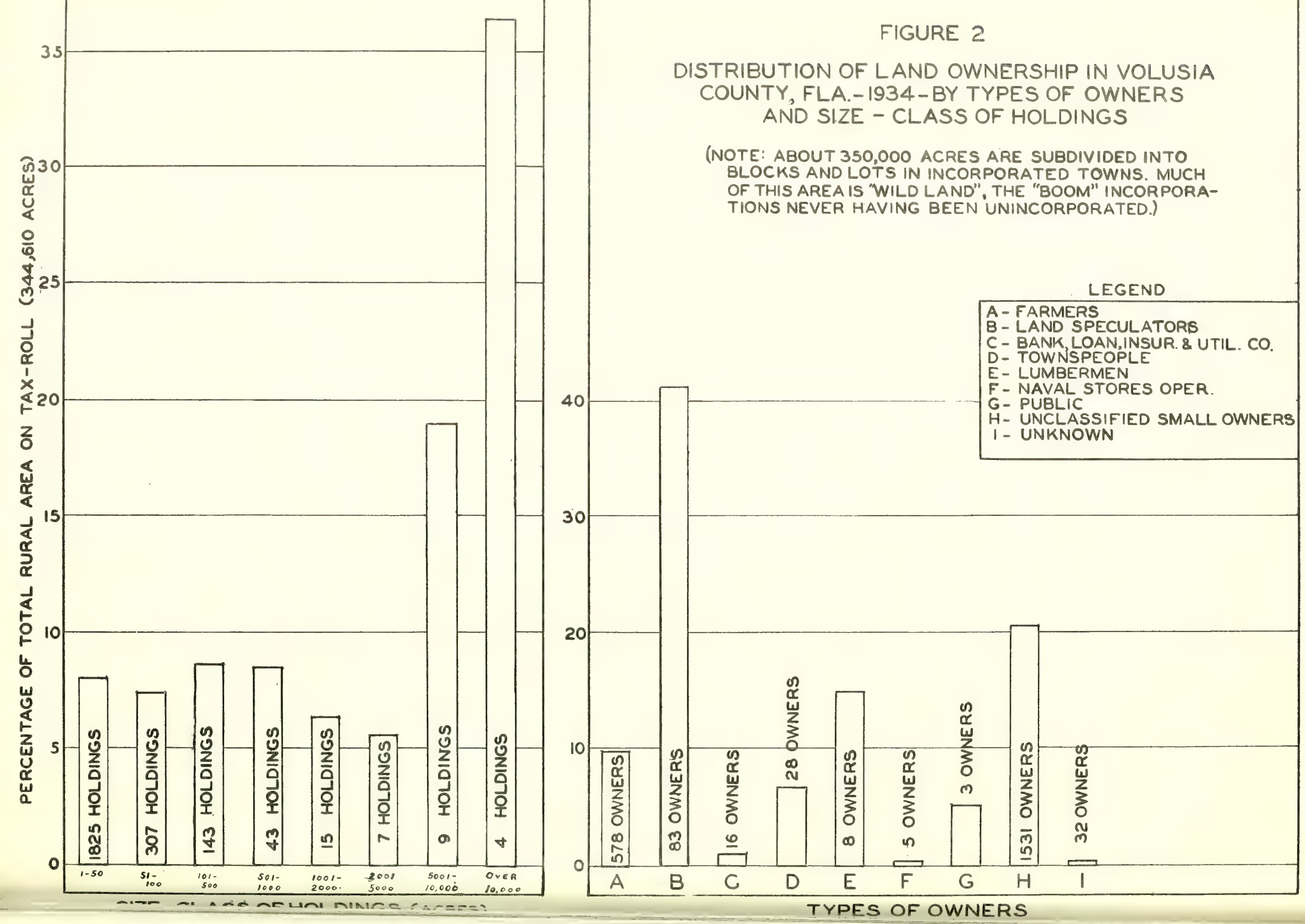


FIGURE 2

DISTRIBUTION OF LAND OWNERSHIP IN VOLUSIA COUNTY, FLA.-1934-BY TYPES OF OWNERS AND SIZE - CLASS OF HOLDINGS

(NOTE: ABOUT 350,000 ACRES ARE SUBDIVIDED INTO BLOCKS AND LOTS IN INCORPORATED TOWNS. MUCH OF THIS AREA IS "WILD LAND", THE "BOOM" INCORPORATIONS NEVER HAVING BEEN UNINCORPORATED.)

The outstanding fact shown by these data is that nearly half the unincorporated rural area of Volusia County is owned by land speculators, both individual and corporate. This condition is undoubtedly the aftermath of the "boom" of 1924-1926, coupled with the facts that land then or later bought for speculation has not been salable during the depression, and that the expected "urban" or "resort" development of these lands never materialized even to the point of incorporation, (See footnote 2/, Table 3). Much of this land is seriously involved in tax-delinquency. 4/

The second largest percentage of rural area is owned by nonresidents whose occupations were unclassifiable. Many of these were northern people owning winter-homes here. These holdings are generally small, averaging 46 acres each.

Fifteen percent of the rural area is owned by 8 lumbermen, three of whom hold 98 percent of the 51,804 acres held by this type of owner, the other five owners having only small tracts. Naval-stores operators hold less than half of one percent of the county, although turpentining is not limited, of course, to the forest land owned in fee by operators. As in many other parts of the Unit, most of the naval-stores operations are in leased timber.

Farmers held only 10 percent of the area, and these tracts average about 60 acres each in area, indicating the relatively unimportant place that agriculture holds in this county's economy.

Five percent of the area is publicly owned, exclusive of the area in theoretical public ownership through tax-forfeiture. Seventy percent of the publicly owned area is held by the State of Florida; the federal government and various municipalities own the remainder.

The average holding in Volusia County is 146 acres in area. Based on number of holdings, 78 percent are 50 acres or less in area, and more than 90 percent are less than 101 acres. Based on area, however, 55 percent of the unincorporated rural land of the county is held by 13 owners in tracts of 5000 or more acres each. Expressed in another way, less than one percent of the number of owners of rural property control more than 55 percent of the rural area.

Farm Woodland Group

The four counties comprising this group all lie along the Florida-Georgia state line. (See Fig. 1). Data on the character of population, gross area, and principal agricultural and forest products are shown in Table 2. The principal species of timber are longleaf and slash pine, with a belt of mixed loblolly pine and hardwoods running southeasterly through central Hamilton and southern Columbia counties.

The southeastern third of Baker County and the southern half of Columbia County more nearly resemble the Agricultural-Naval Stores counties to the south, but, since the county is the unit basis for the data, all of these two counties were included in the Farm Woodland Group. Columbia is the sample county most representative of conditions in this group. Detailed data on the distribution of ownership of its rural land are shown in Table 4 and Figure 3.

4/ A detailed discussion of tax-delinquency in Unit #1, is presented in a later report--Land Taxation and Tax Delinquency in Survey Unit #1, Florida.

Table 4. - Distribution of Land Ownership by Types of Owners and Size-classes of holdings - Columbia County, Florida - 1934

Type of Owner	Total Owners Per Type		Total Area Per Type	
	Number	Percent	Acres	Percent
Farmers	1,564	61.4	183,131	37.9
Land Speculators	21	0.8	63,755	13.2
Townspeople	196	7.7	33,970	7.0
Bank, Loan, Ins. & Util. Co.	15	0.6	13,004	2.9
Lumbermen	6	0.2	4,370	0.9
Naval-Stores Operators	17	0.7	36,486	7.5
Public	3	0.1	73,635	15.2
Eleemosynary	10	0.4	121	1/
Unclassified small owners	214	8.4	18,784	3.9
Unknown	502	19.7	55,472	11.5
Total	2/2,548	100.0	3/482,728	100.0

Size-Classes of Holdings (Acres)	Total Holdings Per Class		Total Area Per Class	
	Number	Percent	Acres	Percent
1 50	1,322	48.9	28,195	5.9
51 - 100	465	17.2	35,953	7.4
101 - 500	687	25.4	146,990	30.4
501 1,000	191	7.1	121,045	25.1
1001 2,000	19	0.7	26,608	5.5
2001 5,000	14	0.5	37,227	7.7
5001 10,000	3	0.1	20,648	4.3
Over 10,000	2	0.1	66,062	13.7
Total	2/2,703	100.0	3/482,728	100.0

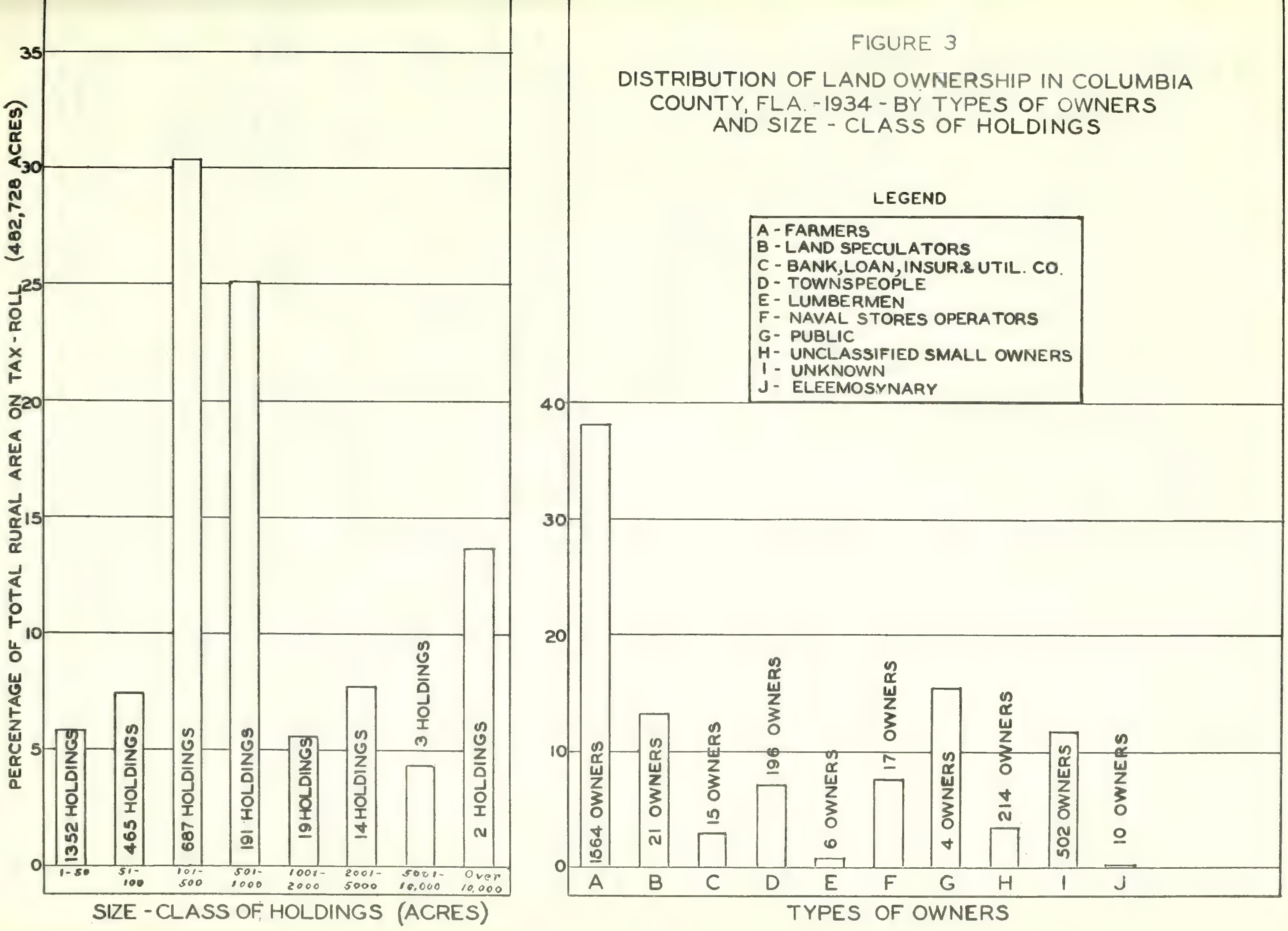
1/ Less than 0.05 percent.

2/ Total number of owners and total number of holdings differ because in one classification three public owners are listed (federal, state, municipal), whereas in the other classification public areas are listed by number of separate holdings per size-class.

3/ Rural land on tax-roll, exclusive of areas within incorporated towns, rights-of-way, and waterways. Above figures include land theoretically forfeited for non-payment of taxes.

FIGURE 3

DISTRIBUTION OF LAND OWNERSHIP IN COLUMBIA COUNTY, FLA. -1934 - BY TYPES OF OWNERS AND SIZE - CLASS OF HOLDINGS



Quite different ownership conditions are shown by these data for Columbia County from those for Volusia. Farmers hold the largest percentage of rural area (38 percent), the farms averaging 117 acres in area, while public agencies own the second largest portion (15 percent). Most of the publicly-owned land is in the Osceola National Forest (72,051 acres). This Forest also extends into Baker County. A large acreage (12 percent) is carried on the tax roll in the name of "unknown" owners. Much of this area is that in current tax-default. The law provides that land in default beyond the last date for payment of current taxes ("delinquency date"), and land not returned for taxation by the last day for filing tax returns, shall be so carried, but very wide latitude in conforming with this law is evidently permitted.

Land speculators, although few in number, held 13 percent of the area, the third largest percentage of any type of owner.

Lumbermen, numbering only six owners, hold less than one percent of the rural area. In the Farm Woodland Group of counties, most of the lumbering operations are on land not owned by the operators, but on farm woodlands and the holdings of other types of owners. The same procedure is common in respect to naval stores operations, most of which are on leased timber, although operators hold over 36,000 acres (7.5 percent of the rural area).

The average holding in Columbia County for all types of owners is 179 acres. Based on number of holdings, nearly half are 50 acres or less in area, and two-thirds are less than 101 acres. One-fourth range from 101 to 500 acres. Five owners (0.2 percent) hold 19 percent of the total area in tracts of 5,000 or more acres. Fifty-six percent of the total acreage is held in tracts from 101 to 1,000 acres each in area.

Lumber Group

The three counties comprising this group all lie along the Gulf Coast. (See Fig.1). Data on the area, population and products of this group are given in Table 2. Most of the rural-farm population is in Levy County, which is the leading agricultural county in the group. Agriculture is relatively unimportant in these counties, the total value of all farm products in 1929 being less than $809,000, or four percent of the total value from the Unit. (4). The timber is chiefly slash and longleaf pine, with cypress and swamp hardwoods in the deeper ponds and bays.

Dixie county is the most representative county in the group. The details of the distribution of its land ownership are given in Table 5 and Fig. 4.

The Lumber Group of counties again presents an entirely different picture of land ownership from the two groups previously discussed. Seventy-two percent of the rural area is owned by lumbermen. Three companies, Brooks-Scanlon Corporation, Putnam Lumber Company, and McRay Sawmills Company, hold 282,476 acres (72.4 percent of the rural area). The only other type of owner to hold any appreciable area is the farmers, who own 20 percent. Naval stores operators hold 2 percent. Public ownership is limited to 1,124 acres (less than one percent), all in federal unappropriated public domain.

The average holding in Dixie County is 1,266 acres in area, the largest unit holding in any county studied. Even if the three large lumber company holdings are excluded, the average ($319\frac{1}{2}$ acres per holding) is still larger

Table 5. - Distribution of Land Ownership by types of Owners and Size-Classes of holdings - Dixie County, Florida, 1934

Type of owner	Total owners Per type		Total area Per type	
	Number	Percent	Acres	Percent
Farmers	139	47.2	78,739	20.4
Land Speculators	2	0.7	568	0.1
Townspeople	19	6.4	1,860	0.5
Bank, Loan, & Insurance Co.	2	0.7	3,972	1.0
Lumbermen	5	1.7	282,876	72.4
Naval Stores Operators	8	2.7	8,597	2.2
Public	1	0.3	1,124	0.3
Unclassified Small Owners	87	29.5	7,172	1.8
Eleemosynary	4	1.3	1,490	0.4
Unknown	28	9.5	3,507	0.9
Total	1/ 295	100.0	1/ 389,905	100.0

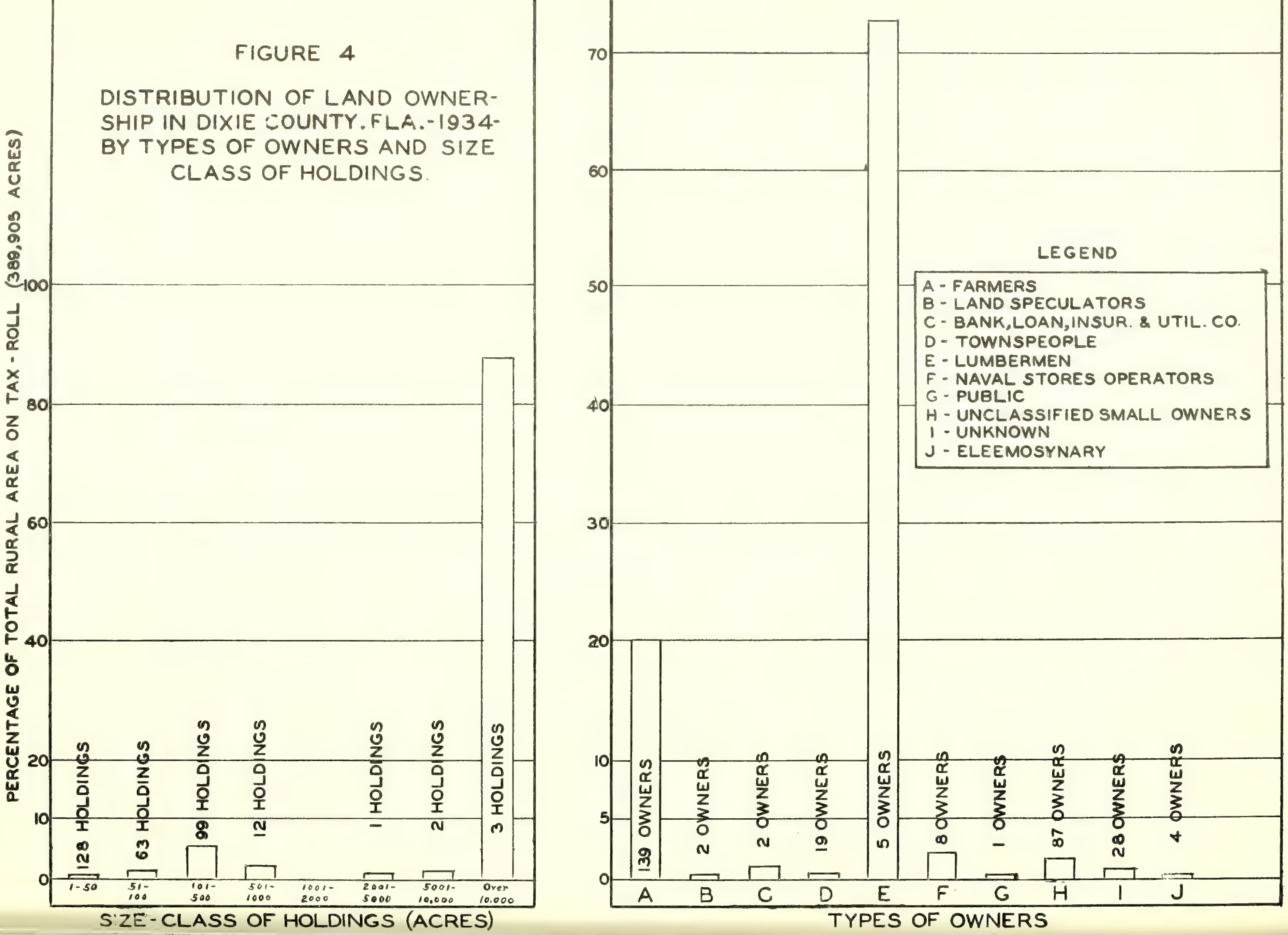
Size-classes of holdings (Acres)	Total holdings per class		Total area per class	
	Number	Percent	Acres	Percent
1 - 50	128	41.5	3,263	0.8
51 - 100	63	20.5	4,819	1.2
101 - 500	99	32.2	21,048	5.4
501 - 1,000	12	3.9	8,200	2.1
1,000 - 2,000	---	0.0	---	0.0
2,001 - 5,000	1	0.3	3,812	1.0
5,001 - 10,000	2	0.6	5,678	1.5
Over 10,000	3	1.0	343,085	88.0
Total	1/ 2/ 308	100.0	1/ 389,905	100.0

1/ Rural land only, exclusive of areas in incorporated towns (Cross City), in rights-of-way and waterways, and of 432 parcels totaling 48,720 acres carried on tax-roll in the name of the State as tax-forfeited.

2/ Total number of owners and total number of holdings differ because in one classification publicly-owned areas are listed as 1 (federal), whereas in the other classification public areas are listed by number of separate holdings per size-class.

FIGURE 4

DISTRIBUTION OF LAND OWNERSHIP IN DIXIE COUNTY, FLA.-1934- BY TYPES OF OWNERS AND SIZE CLASS OF HOLDINGS.



than that of any other county. Ninety percent of the rural area is held by five owners (1.6 percent of total number) in tracts of more than 5,000 acres each. While only 2 percent of the total area is held in tracts averaging less than 100 acres each, 62 percent of the number of holdings are of this size.

In this county, tax-forfeited land is carried on the tax roll in name of the "State of Florida," while the currently delinquent land is carried in the name of "Unknown." The latter areas appear in Table 5; the former do not, since no data were obtained as to their exact status. In all other counties, tax-forfeited land is shown either under some known type of ownership, or under "Unknown" ownership.

Agricultural-Naval Stores Group

The 10 counties comprising this subdivision of the Unit are all interior (see Fig. 1). Data on their area, population, and products are shown in Table 2. This group of counties is the most important of the Unit in agricultural production, the total value of such crops in 1929 being nearly $11,200,000, or 56½ percent of that of the whole Unit. (4). Except for a narrow belt of loblolly pine-hardwoods in the north-central portion and some cypress in scattered stands in the western portion, the timber is almost exclusively slash and longleaf pine.

Alachua County has been selected as the sample county representative of this group. The distribution of its land ownership is shown in Table 6 and Figure 5.

This county's agricultural predominance is shown again by the fact that farmers own 46 percent of its rural area, each farm averaging 115 acres in area; 23 percent is owned by unclassified small owners, whose holdings average only 98 acres in area. Most of their land is in farms or idle. If in farms, it is usually operated by a tenant or a share cropper, or it may be worked on a part-time basis by the owner. Fourteen percent of the rural area is held by townspeople (merchants, professional men, and so forth). Much of this area is also in tenant-operated farms. Hence the area of the county in use as farms comprises well over half the total.

Lumbermen own less than 4 percent and naval stores operators less than one percent of the area. Lumber is not an important product of the county, but naval stores are leading items. As elsewhere in the subdivision, most of the operations are in leased timber. The other important naval stores producing counties in the subdivision are Madison, Union, Bradford, and Clay, although some production and stilling is found in all counties.

Eighty percent of the number of holdings are less than 101 acres in area, although this class comprises but 19 percent of the total rural area, Nearly one-fourth of the total area is in holdings 101 to 500 acres in area, the largest percentage in any one size-class. Ten owners (less than half of one percent of total number) hold 21½ percent of the total area. The average holding in Alachua County covers 129 acres.

Table 6. - Distribution of Land Ownership by Types of Owners and Size-Classes of holdings - Alachua County, Florida - 1934.

Type of owner	Total owners Per type		Total area Per type	
	Number	Percent	Acres	Percent
Farmers	1,957	51.4	224,983	45.9
Land Speculators	34	0.9	38,557	7.8
Townspeople	320	8.4	66,781	13.6
Bank, Loan, Ins., & Util. Co.	18	0.5	9,099	1.9
Lumbermen	3	0.1	17,077	3.5
Naval Stores Operators	10	0.3	3,484	0.7
Public	2	0.1	3,002	0.6
Eleemosynary	2	0.1	100	1/
Unclassified Small Owners	1,143	30.0	112,033	22.8
Unknown	313	8.2	15,836	3.2
Total	2/3,802	100.0	3/490,952	100.0

Size-classes of holdings (Acres)	Total holdings per class		Total area per class	
	Number	Percent	Acres	Percent
1 - 50	2,495	65.5	50,718	10.3
51 - 100	563	14.8	42,624	8.7
101 - 500	583	15.3	117,120	23.9
501 - 1,000	106	2.8	70,380	14.4
1,001 - 2,000	35	0.9	47,719	9.7
2,001 - 5,000	20	0.5	57,062	11.6
5,001 - 10,000	5	0.1	33,407	6.8
Over 10,000	5	0.1	71,922	14.6
Total	2/3,814	100.0	3/490,952	100.0

1/ Less than 0.05 percent.

2/ Total number of owners and total number of holdings differ because in one classification two public owners are listed (federal and state), whereas in the other classification, public areas are listed by number of separate holding per size-class.

3/ Rural land only, exclusive of areas in incorporated towns, rights-of-way, and waterways. Approximately 50,000 acres are in suburban blocks and lots.

FIGURE 5

DISTRIBUTION OF LAND OWNERSHIP IN ALACHUA COUNTY, FLA.-1934-BY TYPES OF OWNERS AND SIZE-CLASS OF HOLDINGS

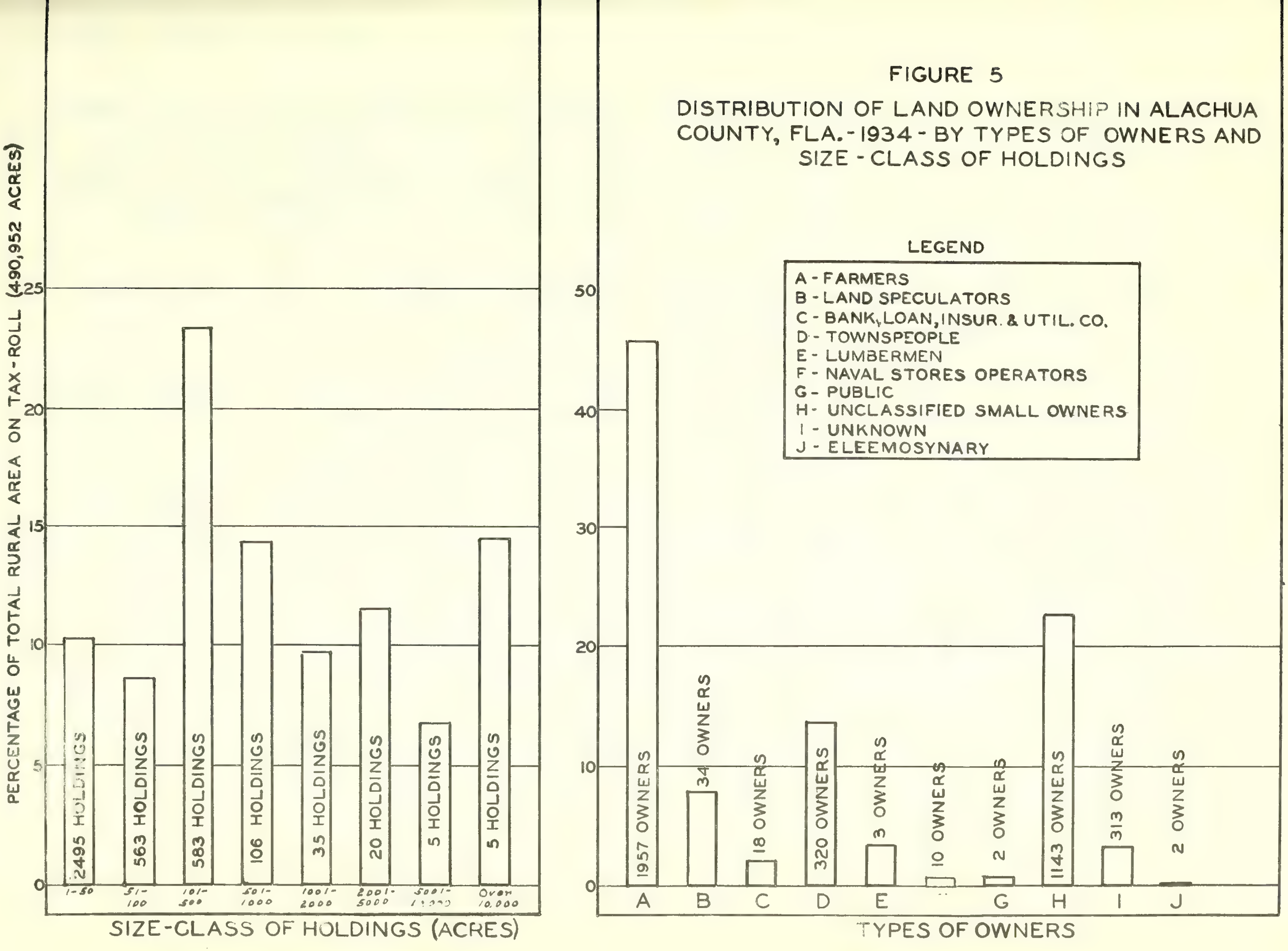


Table 7. - Percentage Distribution of Area by Known Types of Owners - Eight Counties - Florida Unit #1 - 1934.1/

Type of owner	Agricultural-Naval Stores Group			Lumber Group	Farm Woodland Group		East Coast Group	
	Madison	Suwannee	Alachua	Dixie	Columbia	Nassau	St.Johns	Volusia
	Percent							
Farmer	53.7	53.4	47.4	20.4	42.9	16.5	3/42.4	12.1
Land Speculator	8.4	6.5	8.1	0.1	14.9	21.5	23.8	51.9
Townspeople	4.1	16.6	14.0	0.5	8.0	7.1	2.6	8.8
Bank, Loan, Ins., & Util. Co.	1.8	5.5	1.9	1.0	3.1	1.5	2.3	1.2
Lumbermen	12.4	0.4	3.6	73.2	1.0	0.5	12.4	19.0
Naval Stores Operators	19.3	2.9	0.7	2.2	8.5	26.0	7.4	0.6
Public	2/	0.5	0.7	0.3	17.2	0.8	2.3	6.4
Unclassified Small Owners	0.0	14.2	23.6	1.9	4.4	26.1	6.3	0.0
Eleemosynary	0.3	0.0	2/	0.4	2/	0.0	0.5	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total rural area	1/374,381	204,802	475,116	386,398	427,256	226,665	332,980	273,042

1/ Based on recapitulation of ownership data but eliminating areas classified as in "Unknown" ownership, as follows: Madison, 0 acres; Suwannee, 205,786; Alachua, 15,836; Dixie, 3,507; Columbia, 55,472; Nassau, 64,697; St. Johns, 2,922; Volusia, 71,568; Total - 419,788 acres.

2/ Less than 0.05 percent.

3/ Of this 42.4 percent of farmer-owned property, 18.8 percent is "wild land" not in actual use as farms, and 23.6 percent is improved land actually in use as farms.

Table 8. - Distribution of Rural Area by Size-Classes of Holdings - Eight Counties - Florida Unit #1 - 1934

Size-Classes of Holdings	Agricultural-Naval Stores Group			Lumber Group	Farm Woodland Group		East Coast Group	
	Madison	Suwannee	Alachua	Dixie	Columbia	Nassau	St.Johns	Volusia
------- Acres ----------	----------	----------	----------	-- Percent --	----------	----------	----------	----------
1 - 50	3.2	10.9	10.3	0.8	5.9	9.6	6.2	8.0
51 - 100	7.2	18.2	8.7	1.2	7.4	5.6	5.3	7.4
101 - 500	29.7	52.4	23.9	5.4	30.4	22.1	14.5	8.7
501 - 1,000	11.4	8.6	14.4	2.1	25.1	15.3	7.6	8.5
1,001 - 2,000	9.2	2.6	9.7	0.0	5.5	7.4	10.8	6.4
2,001 - 5,000	9.2	4.3	11.6	1.0	7.7	15.7	9.0	5.6
5,001 - 10,000	13.3	3.0	6.8	1.5	4.3	7.9	25.4	19.0
Over 10,000	16.8	0.0	14.6	88.0	13.7	16.4	21.2	36.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total rural area	[1] 374,381	410,588	490,952	389,905	482,728	291,362	335,902	344,610
Size of Average Holding (acres)	266	111	129	1,266	179	134	203	146

1/ Includes land carried as in "Unknown" ownership - Total rural area on tax-roll.

SUMMARY AND CONCLUSION

No attempt is made to derive an average of ownership conditions in the Unit as a whole, since the data do not provide an accurate basis for such a figure. In table 7 are presented data for each of the eight counties studied on percentage of area owned by various types of owners. From this table the area carried on the tax-roll in the name of "Unknown" owners has been eliminated in order to show the actual distribution of known ownership. The areas eliminated are given in footnote 1/ of Table 7. It is obvious that the figures given in Table 7 for the four counties previously discussed will differ from those in Table 3 to 6, owing to the elimination of the "Unknown" classification.

It is evident from this table that farmers own the largest portion of the rural area in five of the eight counties; that lumbermen and naval stores operators together own the largest part in two of the eight; and land speculators the largest percentage in the remaining county. In this Unit the area owned in fee by forest operators is not large, except in the southern lumber group. As stated previously, most of the lumbering and naval stores operations elsewhere in the Unit are in leased timber on land owned by another.

In table 8 is shown the percentage distributions of area by size-class of holdings for all eight counties. In this table the figures for the counties previously discussed are the same as those in Table 3 - 6 respectively. They are shown here for purposes of comparison with the other four counties studied.

In five of these eight counties, the largest percentage of the rural area is held in tracts with an area of 101 to 500 acres each. In Suwannee County, more than half the area lies in tracts of this size. The average holding in each county except Dixie falls in the same size-class. This is in part due to the fact that in this size-class fall the commoner divisions of the units of the public land survey system - quarter section (160 acres); half section (320 acres); three-quarter section (480 acres), as well as intermediate units. In two other counties, the largest percentage of the total area is held in tracts of more than 10,000 acres each, and in one county in the 5,001 - 10,000 class. Practically all such holdings are corporately owned, by lumber companies, agricultural companies, or land-speculating companies except for those in the Osceola and Ocala National Forests. As shown in earlier tables for the four sample counties, and equally true in the other four counties studied, as shown in Table 8, the largest number of holdings fall in the size-classes 1-50 acres, and 51-100 acres, although the percentage of area which falls in these two classes is small.

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PULPWOOD YIELDS FROM EXPERIMENTAL THINNINGS IN OLD-FIELD STANDS OF LOBLOLLY AND SHORTLEAF PINES

By

Henry Bull

Associate Silviculturist

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

PULPWOOD YIELDS FROM EXPERIMENTAL THINNINGS IN OLD-FIELD STANDS OF LOBLOLLY AND SHORTLEAF PINES

By Henry Bull, Associate Silviculturist,
Southern Forest Experiment Station.

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The current expansion of the pulp and paper industry in the South has resulted in an increased need and demand for information on thinning practices applicable to the commercial production of pulpwood from southern pines. In some cases pulpwood constitutes the main crop, but frequently it is desired to cut pulpwood only in thinnings while raising a main crop of high-quality sawlogs, poles, or other products of comparatively high value per unit of volume. It is generally considered that integrated utilization in which pulpwood is cut only in thinnings will yield a much higher net annual return per acre to the average owner than will the production of pulpwood as the only crop.

Granting that pulpwood can be, and for the most part should be and will be, cut in commercial quantities in thinnings, what kind of thinnings are advisable, when and how can they be made to produce the greatest profit, and what will they yield? All of these questions cannot be answered completely at the present time since such answers are usually obtainable only from a large number of permanent sample plots maintained and measured over long periods of time. Complete records of this sort are not yet available in the South. Long before the final outcome of sample-plot studies is known, however, information obtained at interim remeasurements may be put to practical use.

Preliminary data from 25 permanent sample thinning and control plots (including the oldest plots of this kind in the South) are presented in this paper in the belief that figures from actual thinned and unthinned stands are valuable as examples of what certain stands actually produce when given certain treatments. Each plot record to date constitutes a case history of a specific stand that was treated in a given way and that has so far produced and now contains certain amounts of pulpwood. Examples of this sort provide a factual background for the development of pulpwood thinning practices and help in predicting their probable outcome. The reader is cautioned, however, against comparing one plot with another and attempting to use small differences as reliable guides to specific conclusions. The main purposes of this paper are (1) to lend the reality of figures to the general subject of pulpwood thinnings, and (2) to show the large volumes of pulpwood that can be obtained from thinnings while reserving the best trees for a full final crop of sawlogs or other high-quality products.

The plots under consideration are maintained by the Southern Forest Experiment Station in cooperation with the Urania Lumber Company, and are located near Urania, in north-central Louisiana. The plots are entirely in even-aged, old-field stands of loblolly and shortleaf pines, and loblolly is the more common species. The stands were fully stocked to overstocked when the plots were established. Old-field stands constitute only about 10 percent of the entire forest area in the vicinity of Urania, but in some other parts of the South the proportion is much higher. In the Lower Piedmont Region of Georgia, for example, about two-thirds of the entire forested area is occupied by old-field loblolly and shortleaf pines. Regardless of exact regional percentages, this type not only occupies a very large aggregate area in the South but it is a type that is particularly important as a source of pine pulpwood. Old-field stands containing trees of pulpwood size are usually well stocked to overstocked; the growth rate is rapid for at least the first 10 to 15 years; the stands are usually readily accessible; and there is usually a high proportion of trees that will never make high-quality sawlogs, poles or the like, and that should be removed to improve growing conditions for the best trees that will (or should) make up the final crop. Old-field stands should continue to be one of the principal sources of loblolly and shortleaf pine pulpwood for a considerable period.

Since the data presented here were obtained entirely from even-aged old-field stands, the indicated growth rates are directly applicable only to such stands. It is possible, however, to use these data to obtain estimates of growth in relatively pure even-aged stands of loblolly and shortleaf pines on cut-over land by making allowance for differences in density. The simplest way to adjust for density is on the basis of the number of pines per acre. If, for example, for the same age and site quality, a stand on cut-over land contains 60 percent as many trees per acre as an old-field plot for which data are given here, then the growth and yield would be estimated to be 60 percent as great as the values given. For pure or relatively pure even-aged stands, this method of making rough estimates should give conservative values, because with fewer trees per acre the individual trees have more growing space and should therefore be growing faster than if they occurred in more crowded old-field stands. If the stand on cut-over land is not relatively pure pine--i.e., if it contains a large number of hardwoods in the main crown canopy--estimates of growth based on the old-field data presented here will be subject to such large probable errors as to be of little or no value.

Data from 25 plots are presented. Of these, 8 are check or control plots which have never been thinned. The volumes cut and left at establishment and at 5-year intervals thereafter are given entirely in standard rough or unpeeled cords of 128 cubic feet (4 by 4 by 8 feet). They represent the approximate volumes of merchantable pulpwood contained in trees more than 4.5 inches in diameter at breast height and to a flexible top diameter of about 4 inches inside bark. Cords are of course very rough and variable units of volume and it should be clearly understood that the values given here are necessarily approximate and not precise. The cord unit is used because of the general commercial practice of dealing with pulpwood entirely in that unit. The average size of the crop trees, usually intended for high-quality sawlogs on these plots, is roughly indicated by the average diameter of the 100 largest trees per acre.

The figures given on pages 5 to 9 largely speak for themselves, but a few points of special interest deserve brief mention:

(1) Most of the thinnings, especially the earlier ones, were relatively light and removed only the smaller trees (as shown by the smaller average d.b.h. of the trees cut). In some cases the thinnings were so light that pulpwood-size trees in the residual stands died before the next thinning (although this was not always due entirely to competition).

(2) The average annual mortality per acre for a 5-year period in trees of pulpwood size in unthinned plots amounted to less than 0.1 cord in stands up to 20 years old, ranged from less than 0.1 to about 0.7 cord in stands 21 to 30 years old, and ranged from about 0.3 to 0.7 cord in stands 31 to 37 years old. Stands in the last age group are evidently on the threshold of high mortality of pulpwood-size trees, because these stands still contain some 3 to 5 times more trees than will be present in the final crop, and all of the trees are already of pulpwood size.

(3) The average annual growth in pulpwood volume for a 5-year period in thinned stands has ranged from 0.7 to 2.7 cords per acre, with most stands adding from 1 to 2 cords annually. The similar growth in unthinned stands has ranged from 0.1 to 2.9 cords per acre, with approximately the same median growth as in the thinned stands.

(4) Starting at about 20 years, on all but the poor sites, a heavy thinning that removes about one-half of the entire pulpwood volume will yield at least 10 cords per acre and still leave the best (straighest, cleanest, fast-growing, sound) trees for possible increased growth and at least one more good cut of pulpwood before the final harvest of sawlogs or other relatively high-quality products.

(5) The best thinning practices--those most profitable in the long run--are not yet certain. Early thinnings produce little or no pulpwood and may produce limby trees, but should increase the growth rate of the residual trees if made early enough and heavy enough. Late thinnings produce large volumes of pulpwood and relatively clean trees, but are usually too late to increase the growth rate of the residual trees and may be too late to save a considerable volume of pulpwood from loss through mortality. This uncertainty as to the very best practice, however, should not deter anyone from thinning for pulpwood. A timber owner may not make the last possible cent from his timber, but almost any kind of a thinning that removes pulpwood in profitable quantities and still leaves plenty of the best trees for a final crop of higher-quality products will increase both his immediate income and the value of his forest.

Notes on the Data Presented on the Following Pages

Sample plots with the same name (e.g., Maxwell, Castor, etc.) are in the same old-field stand and are therefore grouped together.

After the name and number of each plot there are listed, in order: (1) the principal species of pine and its percentage importance based on representation among the 100 largest trees per acre; (2) the site quality; and (3) the type of thinning, if thinned. "Thinning from below" refers to the cutting of only the smaller trees with very little or no opening up of the dominant, upper, or principal crown canopy. "Crown thinning" refers to a cutting that opens up the dominant crown canopy through the removal of some of the larger trees. The degree or heaviness of thinning is not given since it is necessarily arbitrary and relative, and since the actual record of trees and cords cut and left in each instance speaks for itself.

Most of the sample plots are rather small (most common size: $\frac{1}{4}$-acre) but the listed data are uniformly based on 1 acre.

"D.B.H." stands for diameter at breast height; i.e., at $4\frac{1}{2}$ feet above the ground.

In certain instances, "pines 5" d.b.h. and more" are listed separately because these are all the pines of pulpwood size--in general commercial practice and as used in this paper.

"Ave. height of dom. and codom. loblolly pines" refers to the average height of the dominant and codominant loblolly pines, i.e., the average height of the main crown canopy of the more common species.

"Average d.b.h." is the diameter corresponding to the average basal area, determined by dividing the total basal area by the total number of trees.

DATA FROM PERMANENT SAMPLE PLOTS. BASIS: 1 ACRE.

THINNED PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines		Range in d.b.h.		Average d.b.h.				Approx. volume in rough cords	
							Left		Cut			
			Left	Cut	Left	Cut	All pines	100 largest in d.b.h. per acre	All pines	Pines 5" d.b.h. and more	Left	Cut
	Years	Feet					Inches					
MAXWELL U-5: 75% loblolly in 1915; 100% loblolly in 1935. Good site. Thinnings from below.												
1915	8		1,144	688	0- 5	0- 3	1.6	3.2	0.8	-	0	0
1920	13	29	1,256	160	0- 7	0- 7	3.7	6.3	2.9	7.2	6.2	0.1
1925	18	45	424	468	3- 9	1- 8	6.3	8.0	4.2	5.5	15.4	4.5
1930	23	54	320	68	5-11	4- 9	7.8	9.3	6.4	6.5	22.8	3.0
1935	28	62	232	88	5-12	5-12	8.8	10.1	8.4	8.4	24.5	8.4
TOTAL												16.0
MAXWELL U-55: 100% loblolly. Good site. Crown thinnings.												
1925	18	50	488	296	2-10	3- 8	5.6	7.9	5.2	6.0	13.8	5.5
1930	23	56	288	144	3-12	4- 8	7.2	9.4	5.7	5.9	17.5	4.1
1935	28	67	156	84	3-14	7-13	8.5	10.0	9.2	9.2	16.2	10.5
TOTAL												20.1
MAXWELL U-56: 99% loblolly. Good site. Crown thinnings.												
1925	18	47	772	476	2- 8	2- 7	4.6	6.8	4.4	5.5	11.4	4.3
1930	23	53	496	144	2-10	4- 9	6.0	8.1	5.1	5.6	17.7	2.6
1935	28	64	308	108	3-12	5-10	6.9	9.0	7.8	7.8	18.6	8.9
TOTAL												15.8

UNTHINNED CHECK OR CONTROL PLOT

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines	Range in d.b.h.	Average d.b.h.		Approx. volume in rough cords	Pines 5" d.b.h. and more that died within 5 years after given date			
					All pines	100 largest in d.b.h. per acre		Number	Range in d.b.h.	Average d.b.h.	Approx. volume in rough cords
	Years	Feet		Inches					Inches		
MAXWELL U-3: 75% loblolly in 1915; 100% loblolly in 1935. Good site.											
1915	8		1,328	0- 4	1.5	3.2	0	0			
1920	13	32	1,280	0- 8	3.7	6.4	7.1	0			
1925	18	49	816	1-10	5.5	8.3	21.7	8	5-7	5.9	0.3
1930	23	59	600	2-12	6.9	9.7	30.8	56	5-7	5.4	1.6
1935	28	69	476	3-14	8.0	10.7	43.4				
TOTAL								64			1.9

THINNED PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines		Range in d.b.h.		Average d.b.h.				Approx. volume in rough cords	
							Left		Cut			
			Left	Cut	Left	Cut	All pines	100 largest in d.b.h. per acre	All pines	Pines 5" d.b.h. and more	Left	Cut
	Years	Feet			Inches							
MAXWELL U-53: 95% loblolly. Fair site.												
All pines 4.6" d.b.h. and larger cut in 1925; all 6.0" d.b.h. and larger cut in 1935.												
1925	18	38	347	555	1-4	4-9	3.4	3.9	6.0	6.0	0	18.6
1930	23	39	314	0	2-6		4.6	5.6		-	3.9	0
1935	28	48	164	128	2-6	6-8	4.5	5.2	7.0	7.0	2.1	6.6
TOTAL												25.2
MAXWELL U-54: 100% loblolly. Good site. Crown thinning.												
1925	18	46	100	664	5-10	1-11	7.5	7.5	5.3	6.5	5.7	15.3
1930	23	54	96	0	6-14	-	9.6	-		-	10.6	0
1935	28	64	96	0	7-15	-	11.2				17.1	0
CASTOR U-14: 100% loblolly. Very good site. Thinnings from below.												
1915	21	63	352	208	5-11	4-8	7.8	9.5	6.1	6.1	29.5	9.4
1920	26	72	248	96	6-12	5-8	9.1	10.4	6.6	6.6	31.3	5.6
1925	31	79	244	0	7-14		9.9	11.5			41.7	0
1930	36	84	200	44	7-15	7-9	11.2	12.5	8.1	8.1	46.0	4.5
1935	41	90	180	16	8-17	8-10	12.1	13.3	9.0	9.0	52.5	2.4
TOTAL												21.9
CASTOR U-15: 100% loblolly. Very good site. Thinnings from below.												
1915	21	61	264	364	5-11	4-10	7.8	9.2	6.1	6.4	21.5	15.4
1920	26	69	184	80	6-13	5-9	9.2	10.2	7.0	7.0	23.8	5.3
1925	31	79	184	0	7-15		10.4	11.6		-	34.5	0
1930	36	85	140	44	8-16	8-13	11.8	12.6	9.8	9.8	36.8	7.6
1935	41	88	140	0	9-18	-	12.7	13.5		-	44.5	0
TOTAL												28.3

UNTHINNED CHECK OR CONTROL PLOT

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines	Range in d.b.h.	Average d.b.h.		Approx. volume in rough cords	Pines 5" d.b.h. and more that died within 5 years after given date			
					All pines	100 largest in d.b.h. per acre		Number	Range in d.b.h.	Average d.b.h.	Approx. volume in rough cords
	Years	Feet		Inches					Inches		
CASTOR U-13: 100% loblolly. Good site.											
1920	26	64	416	4-11	7.6	9.5	32.7	24	5-6	5.6	0.9
1925	31	71	392	4-13	8.3	10.6	40.5	72	5-8	6.3	3.7
1930	36	80	320	4-14	9.4	11.6	47.5	44	5-10	7.1	3.3

THINNED PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines		Range in d.b.h.		Average d.b.h.				Approx. volume in rough cords	
							Left		Cut			
			Left	Cut	Left	Cut	All pines	100 largest in d.b.h. per acre	All pines	Pines 5" d.b.h. and more	Left	Cut
	Years	Feet					Inches					
MAYES U-10: 88% loblolly. Poor site. Thinnings from below.												
1915	22	52	344	692	2-11	1- 7	6.4	8.4	3.8	5.3	14.8	4.1
1920	27	56	312	28	3-12	2- 6	7.1	9.1	4.0	6.0	17.9	0.3
1925	32	62	272	40	4-13	4- 8	7.8	9.8	5.9	6.4	21.6	1.4
1930	37	63	272	0	4-15	-	8.2	10.5	-	-	25.2	0
1935	42	67	160	92	4-16	5-13	9.4	10.7	7.5	7.5	21.3	7.2
TOTAL												13.0
MAYES U-11: 86% loblolly. Poor site. Thinnings from below.												
1915	22	51	584	408	2-10	2- 7	5.8	8.0	4.0	5.3	17.9	2.0
1920	27	56	460	112	3-11	2- 8	6.5	8.7	4.1	6.4	21.6	0.6
1925	32	60	360	100	4-12	3- 8	7.2	9.4	5.2	5.4	24.1	2.6
1930	37	63	276	76	5-13	4- 8	8.2	10.2	5.6	5.8	25.7	2.6
1935	42	67	204	72	5-14	5- 9	9.0	10.7	7.1	7.1	24.3	4.8
TOTAL												12.6
MAYES U-115: 82% shortleaf. Poor site. Crown thinning.												
1935	42	69	168	464	3-11	4-12	7.2	8.6	6.4	6.5	12.1	24.3
MAYES U-116: 90% loblolly. Poor site. Crown thinning.												
1935	42	73	68	284	3-16	4-14	11.0	-	7.7	7.9	14.1	24.6

UNTHINNED CHECK OR CONTROL PLOT

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines	Range in d.b.h.	Average d.b.h.		Approx. volume in rough cords	Pines 5" d.b.h. and more that died within 5 years after given date			
					All pines	100 largest in d.b.h. per acre		Number	Range in d.b.h.	Average d.b.h.	Approx. volume in rough cords
	Years	Feet		Inches					Inches		
MAYES U-12: 88% loblolly in 1915; 92% loblolly in 1935. Poor site.											
1915	22	52	928	2-13	5.3	8.7	22.5	12	5	4.8	0.3
1920	27	55	724	3-14	6.0	9.3	26.3	24	5	5.1	0.6
1925	32	63	540	3-14	6.8	9.9	32.1	72	5-7	5.3	2.4
1930	37	65	432	4-15	7.5	10.5	33.1	40	5-6	5.3	1.3
1935	42	68	372	4-15	8.0	11.0	36.2				
TOTAL								148			4.6

THINNED PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines		Range in d.b.h.		Average d.b.h.				Approx. volume in rough cords	
							Left		Cut			
			Left	Cut	Left	Cut	All pines	100 largest in d.b.h. per acre	All pines	Pines 5" d.b.h. and more	Left	Cut
	Years	Feet			Inches							
HOLLY U-2: 96% shortleaf in 1915; 85% shortleaf in 1935. Good site. Thinnings from below.												
1915	12	25x	760	2,448	0- 7	0 5	3.6	5.8	1.1	5.0	2.9	0.3
1920	17	39x	808	0	0-10	-	4.8	7.7	-	-	13.8	0
1925	22	51x	648	168	0-11	2- 5	6.0	8.9	3.6	5.1	25.8	0.4
1930	27	60x	360	96	4-12	5- 8	8.0	9.9	6.1	6.1	32.1	4.4
1935	32	66x	240	112	4-13	7 12	8.5	10.1	8.9	8.9	26.3	13.9
TOTAL		x = shortleaf										19.0
ARNOLD U-70: 100% loblolly. Good site. Crown thinning.												
1928	32	76	156	104	6-18	4-11	11.9	13.2	8.0	8.1	37.4	9.6
1933	37	80	148	0	8-19	-	13.5	13.9	-	-	42.6	0

UNTHINNED CHECK OR CONTROL PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines	Range in d.b.h.	Average d.b.h.		Approx. volume in rough cords	Pines 5" d.b.h.and more that died within 5 years after given date			
					All pines	100 largest in d.b.h. per acre		Number	Range in d.b.h.	Average d.b.h.	Approx. volume in rough cords
	Years	Feet		Inches					Inches		
HOLLY U-1: 50% loblolly in 1915; 92% loblolly in 1935. Fair site.											
1915	12	26	3,912	0- 6	2.2	5.2	2.3	0			
1920	17	37	1,776	0- 8	3.8	6.7	11.0	0			
1925	22	50	1,096	1-10	5.2	7.9	25.0	16	5	5.1	0.4
1930	27	58	848	2-11	6.1	8.9	35.1	40	5	4.7	0.8
1935	32	65	680	2-13	6.9	9.7	42.9				
TOTAL								56			1.2
ARNOLD U-69: 96% loblolly. Very good site.											
1928	32	82	244	4-19	10.7	13.1	49.9	24	6-7	7.0	1.6
1933	37	85	220	4-20	11.5	13.7	53.0				

THINNED PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines		Range in d.b.h.		Average d.b.h.				Approx. volume in rough cords	
							Left		Cut			
			Left	Cut	Left	Cut	All pines	100 largest in d.b.h. per acre	All pines	Pines 5" d.b.h. and more	Left	Cut
	Years	Feet			----------	Inches	----------					
NELSON U-68: 100% loblolly. Good site. Crown thinnings.												
1928	27	64	264	248	6-11	4- 8	8.3	9.4	6.0	6.1	25.8	10.6
1933	32	67	140	116	6-12	6-11	9.3	9.7	8.7	8.7	17.9	12.4
TOTAL												23.0
NELSON U-78: 100% loblolly. Poor site. Crown thinnings.												
1928	27	57	270	220	6-11	4- 8	8.4	9.7	6.1	6.2	24.1	8.5
1933	32	60	85	175	7-12	6-11	10.0	-	8.6	8.6	11.7	16.0
TOTAL												24.5
WHITEHEAD U-65: 100% loblolly. Fair site. Crown thinnings.												
1928	21	52	578	294	2- 9	4- 6	6.2	7.7	4.8	5.3	22.5	4.2
1933	26	54	257	238	3-10	5-10	7.6	8.6	6.8	6.8	17.2	12.0
TOTAL												16.2
ISOM STRANGE U-81: 100% loblolly. Poor site. Crown thinnings.												
1928	21	45	662	252	1-10	4- 7	5.2	7.8	4.6	5.2	14.4	2.4
1933	26	53	402	73	1-11	2-10	6.3	8.6	6.8	7.0	16.4	3.6
TOTAL												6.0

UNTHINNED CHECK OR CONTROL PLOTS

Date	Total age	Ave. height of dom. and codom. loblolly pines	Number of pines	Range in d.b.h.	Average d.b.h.		Approx. volume in rough cords	Pines 5" d.b.h. and more that died within 5 years after given date			
					All pines	100 largest in d.b.h. per acre		Number	Range in d.b.h.	Average d.b.h.	Approx. volume in rough cords
	Years	Feet		--------	Inches	- -- ----			----Inches----		
NELSON U-79: 100% loblolly. Poor site.											
1928	27	57	574	2-12	6.9	9.4	32.1	104	5-7	5.7	3.5
1933	32	60	448	5-13	7.6	10.1	32.8				
WHITEHEAD U-66: 100% loblolly. Good site.											
1928	21	52	752	1-10	6.2	8.7	28.4	20	5	4.9	0.4
1933	26	60	571	1-12	7.6	9.9	40.1				
ISOM STRANGE U-30: 98% loblolly. Poor site.											
1928	21	48	892	2-10	5.3	8.2	20.3	4	5	4.8	0.1
1933	26	55	664	3-11	6.3	9.0	27.1				

OCCASIONAL PAPER No. 58

December 31, 1936

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SOUTHERN FOREST EXPERIMENT STATION
E. L. Demmon, Director
New Orleans, La.

AN INVESTIGATION IN [illegible] PRODUCTION FROM ROUND AND TURPENTINED LONGLEAF PINE

By

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and

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This paper releases information from current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

FOREWORD

Many owners of small as well as of large tracts of forest land in the South are seriously interested in managing their properties for continuous production of sawtimber, naval stores and other forest products. In order to furnish them with authoritative information regarding incomes, costs and most profitable methods of sustained yield forest management, the Division of Economics of the Southern Forest Experiment Station is making comprehensive studies for specific sets of conditions in the different forest regions of the South. The study reported in this paper is one of these and is concerned chiefly with an investigation of pulpwood production in the longleaf-slash pine forest region.

W. E. Bond, In Charge,
Division of Forest Economics,
Southern Forest Experiment Station.

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AN INVESTIGATION IN PULPWOOD PRODUCTION
FROM ROUND AND TURPENTINED LONGLEAF PINE

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I. INTRODUCTION

The present publication reports on an investigation of pulpwood production from round and turpentined longleaf pine made in a locality tributary to a paper mill in the longleaf-slash pine type. This investigation is the first of a series planned to cover all southern forest types in which pulpwood is cut extensively. These studies have the following major objectives: (1) To determine costs under present methods of pulpwood production; (2) To determine stumpage values for specific conditions; (3) To develop improvements in operating equipment and methods, which will reduce operating expense or eliminate waste; and (4) To establish the most profitable utilization practices through comparison of production costs and market values for the various products of timber stands. The present report covers the first two objectives and suggests some improvements in equipment and methods. It is hoped to prove them in later studies. The fourth objective is not covered because production cost data bearing on other products than pulpwood are not yet available.

Pulpwood as a Product of Naval Stores Stands

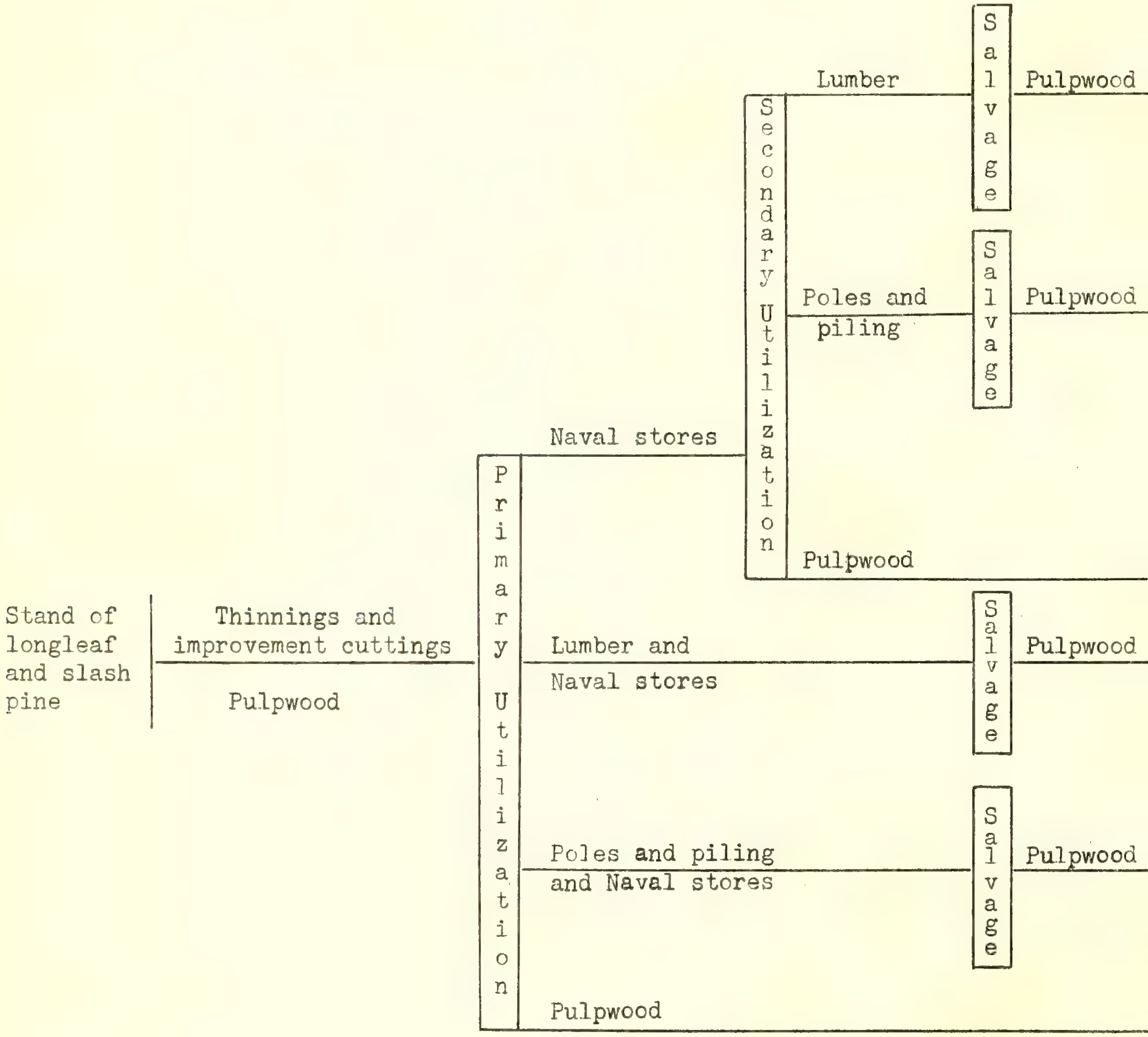
The accompanying diagram, figure 1, illustrates different management schemes for longleaf or slash pine. This portrayal is not assumed to be complete, but it indicates a prominent place for pulpwood combined with other products.

Where seed supply is ample and fire protection adequate, the resultant stands of southern pine seedlings are often very dense - in many cases too dense for optimum growth. In such stands thinnings of the proper kind and at the right time will increase the net growth, and if the size of the material removed is sufficiently large, there is a possibility of using it for pulpwood. The time of thinning will generally be deferred until the material removed can be sold at a profit.

The primary utilization of a stand of longleaf or slash pine may be for naval stores, logs, piling and poles, or for pulpwood. If the primary utilization is for naval stores, the worked-out timber may later be removed in the form of logs, poles and piling, or pulpwood, or a combination of these. Pulpwood may also be salvaged from the tops of trees cut for logs or for piling.

Figure 1.

Illustration of place of pulpwood in the management of longleaf and slash pine



The opinion is current that raising timber for naval stores may well be less profitable in the future than at the present time or in the recent past because of the increasing supply of suitable turpentine stands and the large remaining supply of virgin stumps available for distillation. It may be advisable to use part of one's timber stands or timber lands primarily for the production of lumber or piling. Trees intended for this type of utilization may be worked for naval stores for a few years before cutting; they may form the stand of a certain area, or may be selected individuals in the area devoted to naval stores production.

Selection of pulpwood as the primary yield occurs seldom at present except where, for example, unstable ownership of certain young stands makes it desirable to convert the investment into cash.

Location and Scope of Investigation

The present investigation in pulpwood production was made in the summer of 1934 in turpentined stands of longleaf pine in the longleaf-slash pine type of the Lower Coastal plain. For the most part only worked-out timber was cut, though, through lack or disregard of cutting instructions, some small round timber was also utilized. The cutting data are based upon one day's work for each of eight crews of pulpwood cutters. Seven were two-man crews: the eighth was a three-man crew. Approximately two-thirds of the cutters were white, the rest were colored. There are five tracts represented, on two of which the logs and piling were removed prior to cutting pulpwood. On the remaining three, pulpwood was the only product. The pulpwood cut during the investigation was sold to a local paper mill.

Time requirements for pulpwood cutting expressed in man-hours per cord of 160 cubic feet and per 100 cubic feet of wood 1/ are based upon intensive time studies and measurements of output for trees of different diameter classes, 2/ for the eight crews of pulpwood cutters working in longleaf pine ranging in diameter from 5 to 14 inches. Time required 3/ for each individual operation in

1/ The cord of 160 cubic feet is equivalent to a stack of wood eight feet in length and four feet in height composed of pieces five feet in length. The unit of 100 cubic feet, solid volume, is used to permit comparison between different forest products and between the same product in different localities. For example, the production cost of logs per 100 cubic feet may be compared with that of pulpwood even though the accepted unit of measure for logs is the board foot and for pulpwood the stacked cord. Of course, bark is disregarded in volume computations for the unit of 100 cubic feet of wood.

2/ As diameter breast high cannot be directly measured on turpentined trees because of distortion from growth after turpentining, it must be estimated. In the present report it was determined by increasing the value of the tree diameter at 10 feet above the ground by 9 percent which represents the average relationship between diameters at these two heights for unturpentined trees.

3/ All time of the working day is included in these computations; that is, actual working time plus the prorated portion of the time for rests and delays.

Table 1. - Pulpwood volume table for round and turpentined longleaf pine where all turpentined butts are utilized.

D.b.h. 1/	Basis	Average used length 2/	Top diameter o.b. 3/	Pulpwood volume i.b. 4/	Pulpwood volume o.b. 3/	Ratio of pulpwood vol. o.b. 3/ to vol. of entire tree	Trees per cord of 160 cu. ft. of rough wood
Inches	No. of trees	Feet	Inches	Cu.ft.	Cu.ft.	Percent	Number
5	14	18	3.8	1.7	2.0	82.2	57.2
6	24	26	3.9	3.4	3.9	83.5	29.3
7	34	33	4.1	5.4	6.2	84.4	18.5
8	39	39	4.2	7.8	8.9	85.2	12.9
9	54	44	4.4	10.6	12.0	85.7	9.5
10	37	48	4.6	13.7	15.5	86.2	7.4
11	36	50	4.7	17.0	19.1	86.5	6.0
12	16	52	5.0	20.4	22.7	86.7	5.0
13	8	53	5.2	24.0	26.5	86.9	4.3
14	6	54	5.6	28.4	31.1	87.0	3.7
	268						

1/ Diameter at breast height - 4½ feet above the ground.

2/ Used length means the length of the tree between the stump and the last cut. This length was utilized only when the tree was round or when the turpentined butt was used.

3/ O.b. = outside bark. Limbs are excluded from volume computations.

4/ I.b. = inside bark.

Table 2. Utilization of turpentined timber studied

D.b.h.	Trees studied	Tree with discarded bolts	Turpentined bolts trimmed	Possible pulpwood volume 1/		Tree volume utilized 3/
				Discarded	Utilized 2/	
Inches	Number	Number	Number	Percent	Percent	Percent
6	9	5	0	14.4	85.6	67.2
7	13	8	8	14.3	85.7	69.5
8	32	22	9	14.1	85.9	71.3
9	33	22	10	13.7	86.3	73.5
10	50	36	19	13.1	86.9	75.2
11	33	22	10	12.1	87.9	76.6
12	26	16	10	10.8	89.2	77.7
13	12	6	7	8.9	91.1	78.5
14	9	3	5	6.0	94.0	79.2
	217	140	78			

1/ These percentages were computed from volume used and discarded in each diameter class.

2/ Ratio which actual used-volume bears to volume that would have been utilized if no turpentined bolts had been rejected.

3/ Percentage used-volume bears to entire tree-volume outside bark.

The two bolts nearest the stump received one of the following treatments: (1) Discarded, (2) trimmed and taken, or (3) taken without trimming. Hence figures in column 2 are not the sum of corresponding figures in columns 3 and 4.

pulpwood cutting is shown separately for trees of different diameters. Cutting costs, based on the average rate of earnings for the cutting crews studied, are shown per stacked cord of 160 cubic feet of rough wood and per unit of 100 cubic feet, solid volume, of wood without bark.

Pulpwood transportation by truck, including loading, unloading and hauling, is expressed in the time required and the consequent cost for given hauling distances. Cutting and trucking are the two phases of pulpwood production which place the product at a point where a market value can be applied. This point may be the woodyard of the paper mill or the point of transshipment at railroad or waterway. The difference between sales price and production cost including supervision and incidental costs, represents the sum from which the landowner receives his stumpage and from which the contractor derives his profit and his compensation for risk.

Volume Table and Converting Factor

The results in table 1 are based upon the measurements made of the trees studied in this investigation. Data from this local volume table were used in the computation of tree volumes for this report. The ratio of pulpwood volume to the volume of the entire tree, shown in column 7, is a measure of the relative completeness of utilization. It is quite reasonable to suppose that, as tree diameter increases, the relative degree of utilization should increase as well. The average stump-height for all trees cut was 2.3 feet.

Tree volumes in this study were computed in terms of solid instead of stacked measure. A converting factor is needed to compare cost in terms of solid volume with price in terms of stacked volume. The individual bolts in 6 stacks of pulpwood, comprising approximately 14 cords of 160 cubic feet, were measured. Each stack was selected on the basis of uniformity of bolt size; the average bolt diameter ranged from 4.7 to 16.5 inches. The percentage of solid volume (including bark) per stack varied from 66.1 to 74.3. There was no apparent general trend from one stack to another ranked in order of their average bolt diameters. The average, 71.5 percent, is used in the present report as the relationship of solid to stacked volume for bolts of all diameters.

Two Classifications of Timber Based on Disposal of Turpentined Butts

Most of the timber of this study had been turpentined. If the turpentined portion of these trees had been fire-scarred, in many instances, part or all of the butt was discarded. Table 1, therefore, does not give actual pulpwood volumes under conditions which were encountered. Table 2 is designed to show the extent to which turpentined butts were discarded and the effect on the volume of pulpwood obtained from trees of different diameters. Utilization of the turpentined timber would be regarded as complete if the entire bole suitable for pulpwood were used - in that case each figure in column 6 would be 100.4/ Table 2 represents conditions in a definite locality under certain utilization practices and does not have any general application.

4/ This statement ignores variations in volume due to the "flattened" character of the butts of turpentined trees and assumes that stump heights and unused top lengths would remain unchanged.

Two classifications of pulpwood timber are made in the presentation of cutting data in the present report: Class I, round timber and turpentined timber whose butts were included in the output without trimming of fire-scarred wood; Class II, turpentined timber whose butts were given one of the following treatments for at least a portion of their length: (1) discarded as waste, (2) trimmed and included in the output.

Percentage of Wood and Bark in Pulpwood

Table 3 gives the percentages of wood and of bark in the pulpwood contents of the trees of this investigation. These percentages are not the same as the percentages for unturpentined timber with the same stump heights and top lengths because the discarded turpentined bolts are not included in the calculation and because no allowance is made for the absence of bark on the turpentined faces of used bolts.

II. DESCRIPTION OF OPERATIONS

Pulpwood shipped to the paper mill was supplied almost entirely by contractors. Pulpwood cutting was contracted on a piece-rate basis to cutters who furnished their own tools; the hauling was sometimes sublet to truck owners who drove their own trucks, but usually hauling was done in trucks owned by the contractor or sub-contractor. A foreman was hired to look after the operation if its size warranted it.

Payment for pulpwood delivered at the mill was based on the stacked cord of 160 cubic feet. Deliveries of wood from the sub-contractor were made on this same unit of measurement. Payment to pulpwood cutters for their output was usually on the basis of the number of pens 5/ prepared.

The operations involved in converting standing timber into pulpwood laid down in the woodyard of the mill may be placed under two general heads: (1) Cutting and (2) transport. Within the range of the present investigation, pulpwood production was conducted in the following general manner which may be considered fairly typical of methods in use in turpentined timber in the longleaf-slash pine type.

Cutting

The actual cutting of the timber into pulpwood bolts was done by a crew consisting of two men, usually, though crews of three men were common and sometimes four men worked together. After a tree was felled, limbing and bucking were done in a number of different ways. Sometimes the crew moved toward the top of the tree bucking the bolts as they progressed. When the tree trunk required limbing, the axe-man of the crew limbed a bolt length or more in advance of bucking. Saw pinching was overcome by wooden wedges, by the axe handle used as a lever, or by a specially built "pry-pole." In some cases after the tree was felled and one or two bolts were cut, one man marked and limbed to the limit of utilization, while the second trimmed the charred wood and ingrown bark from turpentined bolts.

5/ The pen, as the term is applied to pulpwood measurement in the South, is a crib of wood six feet in height, with two pieces in each layer.

Table 3. - Percentage[1] of wood and of bark based on rough pulpwood volume of longleaf pine

D. b. h.	Wood	Bark
Inches	Percent	
5	85.4	14.6
6	86.0	14.0
7	86.7	13.3
8	87.3	12.7
9	88.0	12.0
10	88.6	11.4
11	89.3	10.7
12	89.9	10.1
13	90.6	9.4
14	91.2	8.8

1/ These percentages were computed from the volumes inside and outside the bark of that portion of the trees which was used for pulpwood. Stumps, tops, and discarded turpentined bolts are not included. Absence of bark on portions of used bolts was ignored.

The decision on the part of the cutters as to whether or not to trim a turpentined bolt so it would be acceptable by the mill did not rest on any fixed rule. When the landowner did not insist upon this portion of the tree being utilized, it was usually a matter of judgment on the part of the cutters as to whether there would be a greater return with less effort by salvaging the worked-out part of the tree than by cutting additional timber. Where disposition of this portion of the bole was the cutter's option, it was usually utilized if only one face required trimming. If two or more faces needed treatment, the bolt was usually rejected. In those cases where the turpentined faces had not been damaged by fire, it was necessary only to knock off the tins and spikes if they remained after the naval stores operator had abandoned the tree. In this locality, the tin aprons had been inserted in slits prepared with a broad-axe - no tins were nailed to the trees. Quite generally, the discarded bolt was cut five feet long, the same length as the pulpwood bolts. In part, perhaps, this was due to the habit of the cutters who used their saw or a stick for measuring, but a stump two to three feet high and five feet of discarded bolt covered most, if not all, of the turpentined faces which were usually not more than eight or nine feet in height.

None of the bolts of worked-out timber were split, except in the work of one three-man crew. Though many of the bolts exceeded the maximum diameter limit of 12 inches, pieces several inches larger than this limit were accepted by the paper company in the round. Thus, splitting, which is a time-consuming part of pulpwood cutting in trees of large diameter, was of little importance in the present study. All wood was delivered to the mill unpeeled. The bark was removed just before chipping.

In most cases the pulpwood cut was penned by the cutters; in such instances, penning was considered a part of the cutting operation. On one tract the cutters left the pulpwood bolts lying on the ground and were paid on the basis of the number of bolts cut. Trucks are loaded much more readily from pens because the wood is concentrated and much of it lies at a convenient height for loading. Loading from pens eliminates many moves of the truck and reduces considerably the distance that the loaders must travel to complete the load.

Transport

The initial means of pulpwood transportation in all cases studied was the $1\frac{1}{2}$-ton motor truck. In some instances the truck was driven directly to the mill with its load. Since the timber which lay within the radius of profitable truck haul of the mill had been largely cut away, it was more common to use the truck as a supplement to the railroad car or barge, or to both. In such instances, the truck was employed to relay the wood from the place of cutting to a loading point on a railroad or waterway.

Loading and unloading trucks, freight cars, and barges was done wholly by hand labor though the unloading was expedited for carloads and bargeloads at the woodyard of the mill through the use of conveyors.

III. RESULTS OF INVESTIGATION

Cutting

The volume basis for the information shown in Tables 4, 5, 7, and 8 is shown in the following text table:

Cutting crews	(number)	8
Trees		
Round	(number)	51
Turpentined	(number)	217
Total	(number)	268
Volume outside bark 1/		
Pulpwood	(cu.ft.)	3,362
Pulpwood	(cords) 2/	29.4
Discarded bolts	(cu.ft.)	390
Discarded bolts	(cords)	3.4
Total	(cu.ft.)	3,752
Total	(cords)	32.8

1/ Volume between stump and last cut.
2/ Cord of 160 cubic feet of rough wood.

Cutting for Class I.[6] Pulpwood Timber

Itemized costs in man-hours for cutting round trees and turpentined trees whose butts were included in the output without trimming are given in table 4.

Since the three operations of pulpwood cutting - felling, bucking, and limbing are itemized, a fairly accurate estimate may be made, if desired, of the probable time and cost of cutting southern pines of the non-turpentined

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6/ Defined on page 5.

species. If height and form of the trees are assumed to be like those here reported, the only operation that is apt to be appreciably different is limbing. Undoubtedly it will be greater in shortleaf, loblolly, or pond pines. But even if limbing time were doubled to allow for bushier crowns, the cutting cost would not be appreciably changed. It is therefore reasonable to assume that on this basis a fair estimate of relative cost of cutting is possible for those pine species for which no cutting data were taken.

The contents of table 4 are shown in graphic form in figure 2.[7] The time requirements for penning [8] are also included, in order to arrive at a value for total time for cutting. This illustrates the comparative time-requirements of the three operations of pulpwood cutting. Bucking is the major one and felling exceeds limbing. This relationship of limbing and felling might readily be reversed with open-grown longleaf pine or with pine species having larger crowns.

Cutting for Class II.[9] Pulpwood Timber

In the present study there were few round trees and the turpentined timber lost some of its volume in the turpentined bolts which were discarded. The time required for cutting and trimming pulpwood from turpentined timber is shown in table 5. The cutting time per unit volume for trees of each size is increased over the required time for round timber given in table 4 not only because of the reduced volume per tree due to discarding a portion of the turpentined butt, but also because of the time required to trim some of the bolts included in the output. The trimming time per turpentined bolt, 0.05 man-hours, was taken as the same in all diameter classes. Twice as much time was required to prepare pulpwood from 6-inch trees as from 14-inch trees.

Penning Pulpwood

The time required to build pens of pulpwood was also assumed for purposes of this report to be the same per unit volume for trees of all sizes. This was 1.07 man-hours per cord of 160 cubic feet or 1.06 man-hours per 100 cubic feet of wood alone - solid volume.

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[7] In figure 2 the values in man-hours per unit of volume for each curve are read directly from the scale on the side of each graph. Cutting in the upper portion of the figure is the sum of felling, bucking, and limbing; in the lower part of the figure, cutting includes felling, bucking, limbing, and trimming of turpentined bolts which are not shown separately. Penning is not shown by itself in figure 2; it is assumed to be the same per cord or per unit of 100 cubic feet for all diameter classes - see paragraph on "Penning Pulpwood."

[8] See paragraph on "Penning Pulpwood."

[9] Defined on page 5.

Table 4. - Time[1] in man-hours for felling, bucking,[2] and limbing pulpwood

Class I.[3] Pulpwood Timber

Cutting Operation	Man-hours per cord of 160 cubic feet of rough wood									
	By tree diameters in inches (d.b.h.)									
	5	6	7	8	9	10	11	12	13	14
Felling	2.15	1.25	0.92	0.75	0.64	0.57	0.52	0.50	0.48	0.45
Bucking	3.82	3.57	3.27	2.98	2.73	2.51	2.38	2.28	2.18	2.08
Limbing	1.20	0.76	0.58	0.50	0.45	.42	0.40	0.39	0.39	0.39
Total	7.17	5.58	4.77	4.23	3.82	3.50	3.30	3.17	3.05	2.92
	Man-hours per 100 cubic feet of wood only - solid volume									
Felling	2.20	1.28	0.92	0.73	0.63	0.57	0.50	0.48	0.47	0.43
Bucking	3.90	3.62	3.28	2.98	2.70	2.48	2.33	2.23	2.11	2.00
Limbing	1.23	0.78	0.60	0.52	0.45	0.42	0.40	0.37	0.37	0.37
Total	7.33	5.68	4.80	4.23	3.78	3.47	3.23	3.08	2.95	2.80

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[1] Time required for a crew of two men would be one half of these man-hour values.

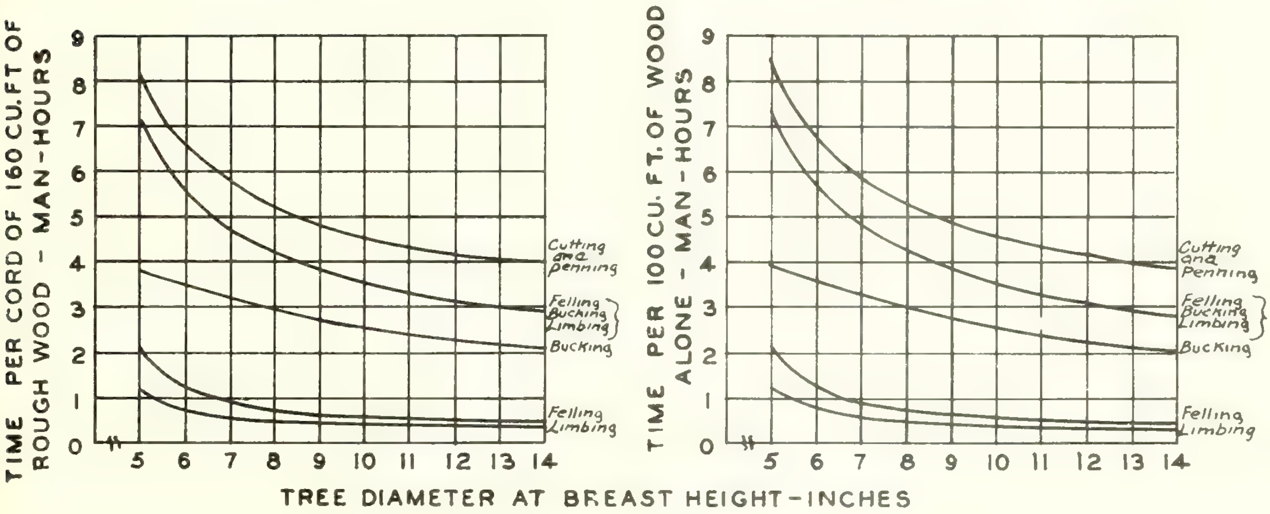
[2] These data are based on pulpwood cutting where the bolts were cut five feet long. If the bolts were cut some other length the bucking time given above would not apply. It is estimated that if the bolt-length were four and one half feet the values for bucking would be increased about 11 percent; if the bolt-length were four feet, bucking time would be increased about 23 percent.

[3] Defined on page 5.

FIG. 2

TIME FOR CUTTING PULPWOOD

CLASS I FOR ROUND AND TURPENTINED LONGLEAF PINE WHEN ALL TURPENTINED BOLTS ARE TAKEN WITHOUT BEING TRIMMED.



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CLASS II FOR TURPENTINED LONGLEAF PINE - ACTUAL CONDITIONS AS FOUND IN THE STUDY, SOME TURPENTINED BOLTS TAKEN, SOME DISCARDED, SOME TRIMMED, AND SOME NOT TRIMMED.

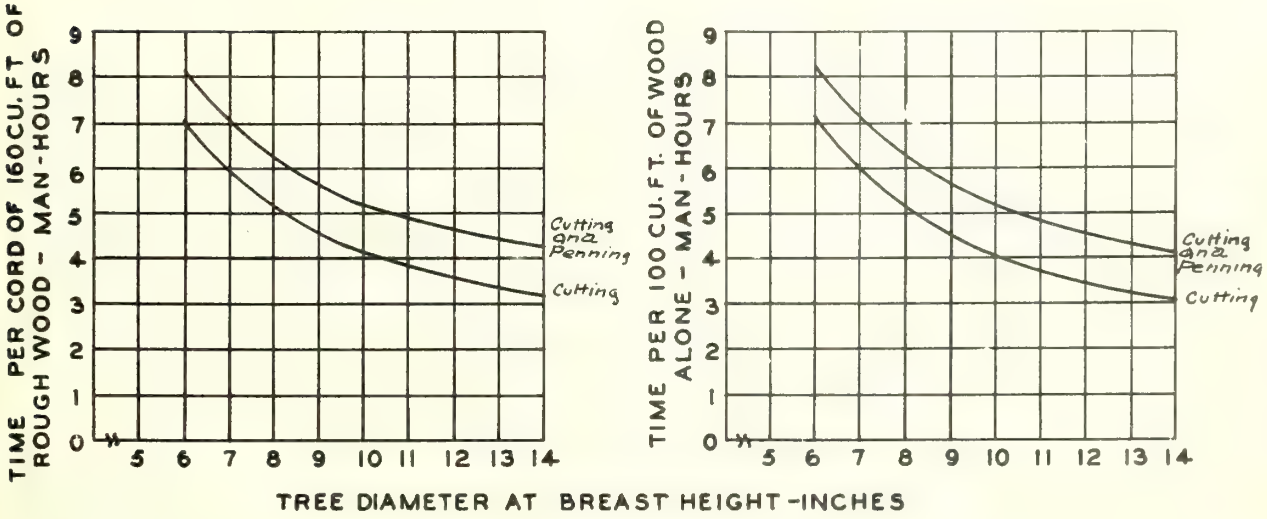

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Table 5. - Time in man-hours[1] for felling, bucking, limbing, and trimming pulpwood

Class II.[2] Pulpwood Timber

D.b.h.	Cutting and trimming time [3]	
	Per cord of 160 cu. ft. of rough wood	Per 100 cu. ft. of wood only - solid volume
Inches	Man-hours	
6	7.05	7.16
7	5.98	6.03
8	5.17	5.18
9	4.59	4.56
10	4.18	4.12
11	3.87	3.78
12	3.66	3.56
13	3.45	3.33
14	3.19	3.06

1/ Time required for a crew of two men would be one half of these man-hour values.

2/ Defined on page 5.

3/ These values may be derived for each diameter class in this way:
- (a) Cutting - Divide corresponding values of table 4 by utilization percent of possible pulpwood volume, table 2, column 6.
- (b) Trimming - Multiply 0.05 man-hours per turpentined bolt (see page 9) by ratio of curved values of turpentined bolts to turpentined trees, table 2, columns 4 and 2. This result is trimming time in man-hours per tree. Change to man-hours per cord or per 100 cubic feet of wood alone by use of volumes of table 1, columns 6 and 5 respectively, decreased by the utilization percent of table 2, column 6.
- (c) Cutting and Trimming - is the sum of (a) and (b).

Cutters' Earnings

The piece-work system of payment for pulpwood cutting prevailed with all crews studied. Table 6 lists the crews by number, the piece-rate and their earnings for the day of the investigation. The earnings shown in table 6 - 14.7 cents per hour - include an allowance for tool maintenance and depreciation of 1.7 cents per man-hour. Cost of supervision, paid by the contractor and estimated at 0.9 cents per hour, was not included. The rate of pay for labor alone was, therefore, 13.0 cents per hour and the average cost of labor to the contractor was 15.6 cents per hour.

Costs of Cutting and Penning Pulpwood

Pulpwood cutters are paid at a fixed rate, generally per pen. Tables 4 and 5 show that much more time is required to cut a cord of pulpwood from small trees than from large trees. This is also true when the pen rather than the cord is the unit of measure. Only by cutting in all diameters are laborers' earnings kept uniform. If timber of the smaller diameter classes alone were cut, the earnings of the cutters would be greatly reduced. Unless they would continue to work at reduced wages, thereby shouldering the extra cost themselves, the contract rate of the cutters would have to be increased. Similarly, if trees of the larger diameter classes alone were cut, the cutters' earnings would be advanced above the general wage level and the contractor would be paying more than average to have the pulpwood cut. The rate paid per pen is therefore actually controlled by the earnings of the cutters and in the last analysis by the size of the timber cut. In order to obtain comparable costs of cutting and penning pulpwood from trees of various sizes the average hourly wage (table 6) was applied to the man-hours (tables 4 and 5) required to cut and pen pulpwood in each diameter class. The results (tables 7 and 8) are the total costs to the contractor, including labor, tools, and supervision by the foreman in charge of the operation. The results bring out the fact that costs of producing pulpwood are much greater in small than in large diameter classes. The costs for 6-inch trees are about double those for 14-inch trees.

Table 6. - Gross daily earnings and hours of pulpwood cutters - for the day of the time-study in each case - cutting round and turpentined longleaf pine

Crew Number	Contract rate	Men per crew	Total time worked [1]	Total earnings per crew [2]	Rate per man-hour	Daily earnings per man
		Number	Hours			
4	70¢ per 100 bolts	2	8.9	$2.37	$0.133	$1.18
5	18¢ per pen	3	8.3	2.96	.119	.99
6	20¢ per pen	2	8.7	3.60	.207	1.80
7	20¢ per pen	2	8.9	1.53	.086	.77
8	20¢ per pen	2	9.3	2.20	.118	1.10
9	20¢ per pen	2	8.4	3.88	.231	1.94
10	20¢ per pen	2	6.3	1.73	.137	.86
Average			8.4	2.46	.147	1.23

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[1] Excluding time spent filing tools.

[2] These earnings include the cost of tools and their upkeep which must be deducted to obtain the rate of payment for labor alone which averages $0.13 per man-hour.

Table 7 - Time and cost[1] of pulpwood cutting

Class I.[2] Pulpwood Timber

D.b.h.	Per cord of 160 cu. ft. of rough wood				Per 100 cu. ft. of wood only - solid volume			
	Time		Cost		Time		Cost	
	Cutting	Cutting and penning[3]	Cutting	Cutting and penning[3]	Cutting	Cutting and penning[3]	Cutting	Cutting and penning[3]
Inches	Man-hours		Dollars		Man-hours		Dollars	
5	7.17	8.24	1.12	1.28	7.33	8.39	1.14	1.31
6	5.58	6.65	.87	1.04	5.68	6.74	.89	1.05
7	4.77	5.84	.74	.91	4.80	5.86	.75	.92
8	4.23	5.30	.66	.83	4.23	5.29	.66	.83
9	3.82	4.89	.60	.76	3.78	4.84	.59	.76
10	3.50	4.57	.55	.71	3.47	4.53	.54	.71
11	3.30	4.37	.51	.68	3.23	4.29	.50	.67
12	3.17	4.24	.49	.66	3.08	4.14	.48	.65
13	3.05	4.12	.48	.64	2.95	4.01	.46	.63
14	2.92	3.99	.46	.62	2.80	3.86	.44	.60

Table 8. - Time and cost[1] of pulpwood cutting

Class II.[2] Pulpwood Timber

D.b.h.	Per cord of 160 cu. ft. of rough wood				Per 100 cu. ft. of wood only - solid volume			
	Time		Cost		Time		Cost	
	Cutting	Cutting and penning[3]	Cutting	Cutting and penning[3]	Cutting	Cutting and penning[3]	Cutting	Cutting and penning[3]
Inches	Man-hours		Dollars		Man-hours		Dollars	
6	7.05	8.12	1.10	1.27	7.16	8.22	1.12	1.28
7	5.98	7.05	.93	1.10	6.03	7.09	.94	1.11
8	5.17	6.24	.81	.97	5.18	6.24	.81	.97
9	4.59	5.66	.72	.88	4.56	5.62	.71	.88
10	4.18	5.25	.65	.82	4.12	5.18	.64	.81
11	3.87	4.94	.60	.77	3.78	4.84	.59	.76
12	3.66	4.73	.57	.74	3.56	4.62	.56	.72
13	3.45	4.52	.54	.71	3.33	4.39	.52	.68
14	3.19	4.26	.50	.66	3.06	4.12	.48	.6

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[1] The wage rate per man-hour is $0.156.

[2] Defined on page 5.

[3] Penning is assumed to require the same time and cost per unit volume for all tree sizes.

	Time	Cost
	Man-hours	Dollars
Per cord of 160 cu. ft. of rough wood	1.07	0.167
Per unit of 100 cu. ft. of wood only - solid volume	1.06	0.165

Trucking Pulpwood

Pulpwood production up to the point of trucking is a hand-labor process with cheap and simple tools. A saw, with handles, and an axe, at something less than \$4 and \$2 respectively, are the main items of expense. Other implements, such as wooden wedges, "pry-pole," oil bottle, and measuring stick, are of nominal value. Pulpwood trucking, on the contrary, demands a relatively large outlay for equipment. A new $1\frac{1}{2}$-ton truck, equipped for hauling, costs approximately \$750. Ownership charges, such as interest and depreciation, and operating costs, other than labor, comprise the largest item of cost in truck operation.

Trucking of pulpwood from two operations was studied for the volume handled and for the time involved in each subdivision of the process. Information on operating expense was obtained from the contractors insofar as possible.[10/] Complete cost records for pulpwood trucks were not available. Certain items of operating expense such as tire and fuel consumption could be estimated rather accurately. Other items such as repairs could not be closely estimated in any case. It is obvious that cost of such items would vary depending upon the age of the truck, the care given it, and the type of road over which hauling takes place. In view of the incomplete state of cost data it was thought advisable to construct an operating budget based as much as possible on cost factors which were known or were susceptible of estimate. Table 9 shows a budget based on starting with a new truck purchased, as most pulpwood trucks are, on the time-payment plan. By trading-in the truck for a new one at the end of a year's use, repairs are kept at a minimum. This operating budget is based upon distance travelled for such items of expense as fuel and tires, and upon time -- i.e., a year -- for such items as wages, supervision, and insurance and capital charges. These latter items of expense are estimated to be \$0.042 per mile and \$1,264.00 per year (\$5.06 per day for 250 days of operation).

There is ample justification for considering that hauling costs based on rough wood volume are uniform throughout the range of tree diameters. It was assumed that solid volume of pulpwood in a stack was uniform regardless of bolt size.[11/] It was found that the truck-load height tended to remain constant throughout the day's operation. As load length was fixed and load height tended to remain constant, the stacked volume of pulpwood hauled was approximately the same for any one operation irrespective of bolt or of tree diameter.

The assumption of uniform loading and unloading costs for pulpwood bolts cut from trees 5 to 14 inches in diameter is made for the purpose of the present report. Loading and unloading costs are relatively insignificant compared with hauling costs for distances as long as those of this study. The variation in the cost of loading and unloading would not greatly affect the total - see table 10.

[10/] Operating cost data were obtained from two other pulpwood contractors in the locality.

[11/] See page 4.

Table 9. - Operating budget[1] for 1½-ton truck hauling pulpwood

	Per Mile	Percentage of total
I. Costs chargeable to distance travelled		
A. Current operating costs		
Gasoline (8.3 miles per gal. 20¼¢ per gal.)	$ 0.0244	58.6
Oil (444 miles per gal. - 64¢ per gal.)	0.0014	3.4
Grease and greasing	0.0009	2.2
Tires ($197.70 per set of 6 - estimated life 15,000 miles)	0.0132	31.7
Maintenance and repairs (estimated at $50.00 for 30,000 miles)	0.0017	4.1
Total operating cost per mile	$ 0.0416	100.0

	Per Year	Percentage of total
II. Costs independent of distance travelled		
A. Current operating costs		
Labor - driver's and helper's wages (250 days per year at $3 per day - total)	$750.00	59.3
Supervision (250 days per year at $0.40 per day)	100.00	7.9
Uninsured risks (5% of average investment)	25.72	2.0
Total current operating costs per year	$875.72	69.2
B. Ownership costs		
Depreciation (Purchase price less tires $556.00 Trade-in value after 1 yr. 275.00 $281.00)	$281.00	22.2
Interest 8% on down payment of $300.	24.00	1.9
Finance charges on unpaid balance of $453.70	45.37	3.6
License fee and title charge	27.25	2.2
Fire and theft insurance on unpaid balance of $453.70	10.66	0.9
Total ownership costs per year	$388.28	30.8
Total costs per year independent of distance travelled	$1,264.00	100.0
Total costs per day - 250 days	5.06	

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[1] This budget is patterned in its essentials after Rapraeger, E. F. Motor truck log hauling in Oregon and Washington. Timberman 34: 12: 18-24. October, 1933.

Table 10. - Time and estimated costs of pulpwood trucking, crew of 2 men, rough wood.

	Loading		Unloading		Hauling					Hauling loading and unloading
					Based on time		Based on distance		Total hauling	
	Hours[1]	Dollars[2]	Hours[3]	Dollars[2]	Hours[5]	Dollars[2]	Miles	Dollars[6]	Dollars	Dollars
Length of haul - 12.2 mi.										
Per load[4] of 177 cu. ft. - solid volume	0.62	0.25	0.32	0.13	1.87	0.75	24.4	1.02	1.77	2.15
Per cord[7] of 160 cu. ft. - stacked volume	.40	.16	.20	.08		.49		.66	1.15	1.39
Length of haul - 26.1 mi.										
Per load[4] of 152 cu. ft. - solid volume	.42	0.15	.23	0.08	3.16	1.14	52.2	2.19	3.33	3.56
Per cord[7] of 160 cu. ft. - stacked volume	.32	.11	.17	.06		.86		1.65	2.51	2.68

	12.2 mile haul	26.1 mile haul
[1] Loading time based on two-man crews loading from pens. Number of loads	4	5
[2] Working time per day in hours	12.7	13.9
Truck-rate per hour - based on daily rate of Table 9	$0.40	$0.36
[3] Unloading time based on two-man crews unloading into stacks 8 ft. high Number of loads -	11	11
[4] Number of loads	12	11

[5] Average time for the round trip

[6] Cost per mile for distance travelled from table 9 - $0.042.

[7] Cord of 160 cubic feet of stacked wood equivalent to 114.4 cubic feet of rough wood - solid volume.

Table 11. - Estimated trucking cost of rough wood based on the unit of 100 cubic feet of wood only - solid volume

D.b.h.	Length of haul - 12.2 miles							
	Loading 1/		Unloading 1/		Hauling 2/		Total trucking costs	
Inches	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
5	0.16	11	0.08	6	1.18	83	1.42	100
6	.16	11	.08	6	1.17	83	1.41	100
7	.16	11	.08	6	1.16	83	1.40	100
8	.16	11	.08	6	1.16	83	1.40	100
9	.16	12	.08	6	1.14	82	1.38	100
10	.16	12	.08	6	1.13	82	1.37	100
11	.16	12	.08	6	1.13	82	1.37	100
12	.16	12	.08	6	1.12	82	1.36	100
13	.16	12	.08	6	1.11	82	1.35	100
14	.16	12	.08	6	1.10	82	1.34	100
	Length of haul - 26.1 miles							
5	.11	4	.06	2	2.57	94	2.74	100
6	.11	4	.06	2	2.55	94	2.72	100
7	.11	4	.06	2	2.53	94	2.70	100
8	.11	4	.06	2	2.51	94	2.68	100
9	.11	4	.06	2	2.49	94	2.66	100
10	.11	4	.06	2	2.48	94	2.65	100
11	.11	4	.06	2	2.46	94	2.63	100
12	.11	4	.06	2	2.44	94	2.61	100
13	.11	4	.06	2	2.42	94	2.59	100
14	.11	4	.06	2	2.41	94	2.58	100

1/ Loading and unloading costs were assumed to be uniform for all tree diameter classes from 5 to 14 inches. The values for this table are equivalent to the corresponding ones per cord of 160 cubic feet divided by 1.144 to reduce them to 100 cubic feet of solid volume of wood and bark, and divided again by 87.9 percent - the weighted average percentage of wood volume to wood and bark volume. As 1.144 x 0.879 = 1.0056, the costs for loading and unloading shown to the nearest cent do not differ in tables 10 and 11 even though the unit of volume measure is not the same.

2/ Stacks of pulpwood from trees 5 to 14 inches in diameter are assumed to have the same volume - solid measure. If the truck loads are piled to the same height, equal amounts of rough wood volume are carried irrespective of the size of trees from which the pulpwood is cut. The amount of wood carried is then proportional to the ratios of wood to wood and bark of table 3. The percentages of table 3 were used to compute these trucking costs for each diameter class by the same method as shown in footnote 1 of this table (table 11).

The basis of truck time and output data in tables 10 and 11 is shown as follows:

Haul	(miles)	12.2	26.1
Time worked	(hours)	12.7	13.9
Trucks	(number)	3	3
Loads	(number)	12	11
Bolts	(number)	1,237	1,427
Bolts	(cu.ft.)	2,118	1,676
Bolts	(cords) [1]	18.7	14.7
Bolts per cord	(number)	66	97
Volume per bolt	(cu.ft.)	1.7	1.2

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[1] of 160 cubic feet.

Data on trucking rough wood per cord of 160 cubic feet, irrespective of tree diameter, are given in table 10 and those per 100 cubic feet of solid volume of wood alone in table 11 for each tree diameter class. The assumption is made that the time and the cost of loading and unloading rough pulpwood is the same per unit volume of wood and bark.[12] The cost of loading and unloading pulpwood, based on the volume of the wood alone, is assumed to be uniform and the method of computing it is explained in footnote 1 of table 11. Hauling cost in table 11 varies for each tree diameter class. As pulpwood on a truck is piled in the same way as on the ground, the same relationship of equal amounts of solid volume for stacks of like dimensions should hold true. The load capacity of trucks hauling pulpwood was determined by the height of the load (which is proportional to stacked volume since the length of the load is fixed) rather than by the weight of the wood carried. If these two considerations are accepted, it is possible to allocate cost of hauling of rough wood on the basis of the unit of 100 cubic feet of wood without bark for each diameter class even though hauling is accepted as uniform, per unit volume of rough wood, for all tree diameters of this present study. The method of computing hauling cost for each tree diameter class on the basis of the unit of 100 cubic feet of wood alone is explained in footnote 2 of table 11.

The trucking data in tables 10 and 11 are shown separately for two hauls from the woods to the mill. The haul of 12 miles was over a woods road for about a mile and over a graded sand road in rough condition for the remainder. The haul of 26 miles was over a woods road for 12 miles and over a paved highway for the remaining 14 miles. No distinction was made in allocating the operating costs of table 9 because of the difference in hauling conditions, though it is recognized that at least two classifications are needed - one for paved and gravelled roads and one for unimproved roads.

In table 10 the load is the unit upon which time requirements of the various operations are based. Costs are shown also per cord of 160 cubic feet of rough wood. The percentage relationship of each hauling item in terms of total trucking cost is shown below:

Length of haul	12.2 miles Percent	26.1 miles Percent
Loading	11	4
Unloading	6	2

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[12] See page 15.

Hauling - based on time	35	32
based on distance	48	62
Total of hauling	83	94
Loading, unloading, & hauling	100	100

The importance of loading trucks to "comfortable" capacity is plain from an examination of table 10. Loading and unloading costs are about 17 and 6 percent of the total trucking cost for the 12 and the 26-mile haul respectively. The greater loading and unloading costs of the 12-mile haul are not to be understood to be due to lesser distance. The hauling costs make up the remainder. More volume per load, within reasonable carrying capacity of the truck, means lessened hauling costs per unit of volume while the loading and unloading costs remain the same. No reason other than the policy of the contractor can be assigned to the markedly smaller loads carried on the longer haul. The stretches of sand and the sharp pitches of adverse grade encountered on this haul were overcome without difficulty. In this instance, each extra cubic foot of wood carried would have helped to reduce the trucking cost. The loads on this haul had a tendency to shift and disintegrate owing to roughness of the road. It is believed that this condition could have been corrected in part, at least, by binding the load to the truck. There are a number of simple devices to obtain tension in chains, which are in common use in trucking, such as a small screw jack placed to put a "bight" in the chain after it is drawn taut by hand or the load binder which accomplishes the same purpose of increased tension by means of lever action. The data on trucking in this present report are too meagre to form a basis of speculation on the load size which is most economical; that is, the load size which shows the lowest cost when all operating expenses are considered. [13]

The following table, made up from the time data which were used in the preparation of tables 10 and 11, shows the time requirements for pulpwood trucking in man-hours:

Unit of measure	Haul of 12.2 miles			
	Loading	Unloading	Hauling	Total
Load of 177 cu. ft. of rough wood - solid volume	1.24	0.64	3.74	5.62
Cord of 160 cu. ft. of rough wood	.80	.41	2.42	3.63
Unit of 100 cu. ft. of wood alone for 10-inch trees - solid volume	.80	.41	2.39	3.60
	Haul of 26.1 miles			
Load of 152 cu. ft. of rough wood solid volume	0.84	0.46	6.32	7.62
Cord of 160 cu. ft. of rough wood	.64	.35	4.76	5.75
Unit of 100 cu. ft. of wood alone for 10-inch trees - solid volume	.64	.35	4.70	5.69

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[13] This economical or optimum load size undoubtedly varies with type of roads.

As noted above these data are expressed in man-hours. As there were two men with each truck the numbers of man-hours per load given in the text table are twice the numbers of "truck-hours" shown in table 10. The difference in man-hour requirements per load for loading and unloading is marked. Comparison of loading and unloading time requirements should be made on the basis of the cord of 160 cubic feet of rough wood or the unit of 100 cubic feet of wood alone - solid volume. On these bases of comparison loading time is 25 percent greater for the 12-mile haul while unloading time is about 17 percent greater. It was apparent to the observers that the efficiency of the truck crews of the shorter haul was markedly lower than that of the crews of the 26-mile haul. It is possible that this factor may explain some of the difference in loading and unloading time. However, it may be seen in the text table on page 19 that the average volume per bolt for the shorter haul was 1.7 cubic feet or 41 percent greater than the average of the longer haul. On a weight basis the bolts of the shorter haul averaged 106 pounds compared with 75 pounds for the other haul. [14] It is probable that the weight of wood handled was a ruling factor in the variation of loading and unloading time. Perhaps it had an effect upon the efficiency of the truck crews.

The man-hours required for hauling vary with many factors such as distance, hauling conditions, drivers, weight of load, and type and condition of truck. Distance and hauling conditions are no doubt the factors of most significance. If the 12-mile haul is used as a base, the 26-mile haul was 114 percent longer while the time required to travel the longer distance was but 96 percent greater. This difference can be partially explained by the better hauling conditions of the longer haul. Such factors as the others enumerated may well account for part of the difference. The solid volume of rough wood carried was 14 percent less for the 26-mile haul. The truck crews of the longer haul were faster loaders; perhaps the drivers were faster as well.

Figures 3 and 4 present the cost data of tables 10 and 11 in graphic form. The cost of cutting and penning from tables 7 and 8 is also shown. These costs for cutting and penning and for trucking are presented as a total production-cost curve (excluding the compensation for risk and for profit). In figures 3 and 4 the comparative costs of cutting and penning and of the costs of trucking are portrayed. Even with the 12-mile haul, trucking costs are the major item; with the 26-mile haul the cutting costs, compared with the total, are of relatively minor significance.

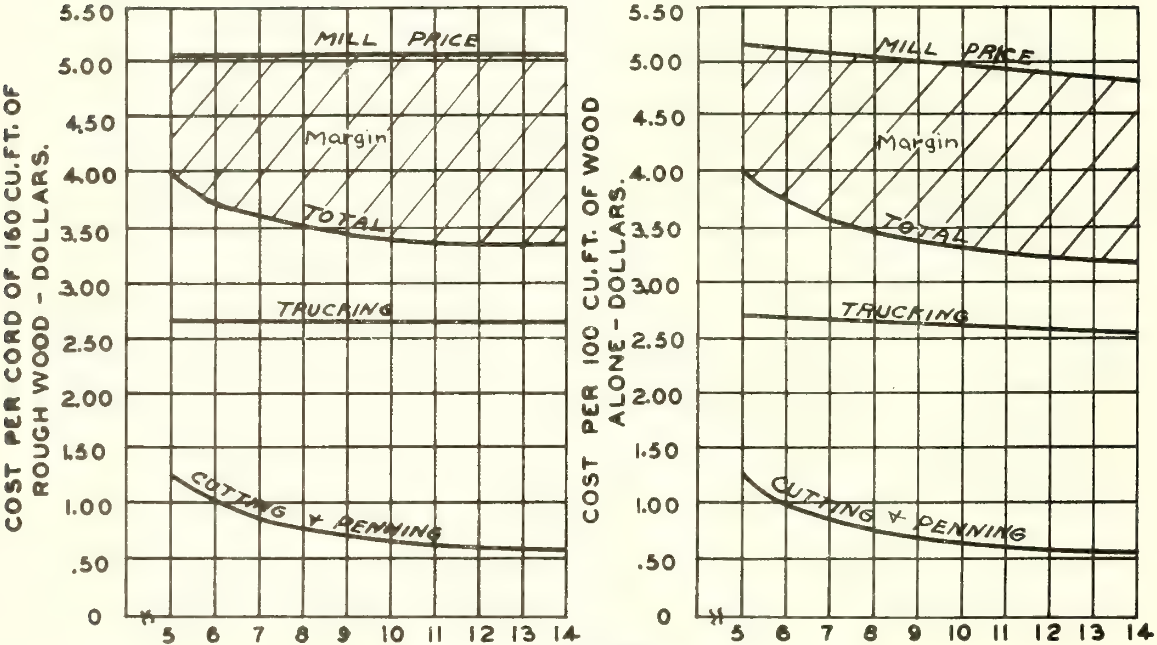
14/ Green longleaf pine pulpwood is about as heavy as water. It was observed that some bolts will float in fresh water while others sink. These weights are calculated on the assumption that pulpwood and water weigh equally per cubic foot.

FIG. 3

SALES PRICE AND PRODUCTION COST OF PULPWOOD

CLASS I FOR ROUND AND TURPENTINED LONGLEAF
PINE WHERE ALL TURPENTINED BOLTS
ARE TAKEN WITHOUT BEING TRIMMED.

TRUCK-HAUL OF 26.1 MILES



TRUCK-HAUL OF 12.2 MILES

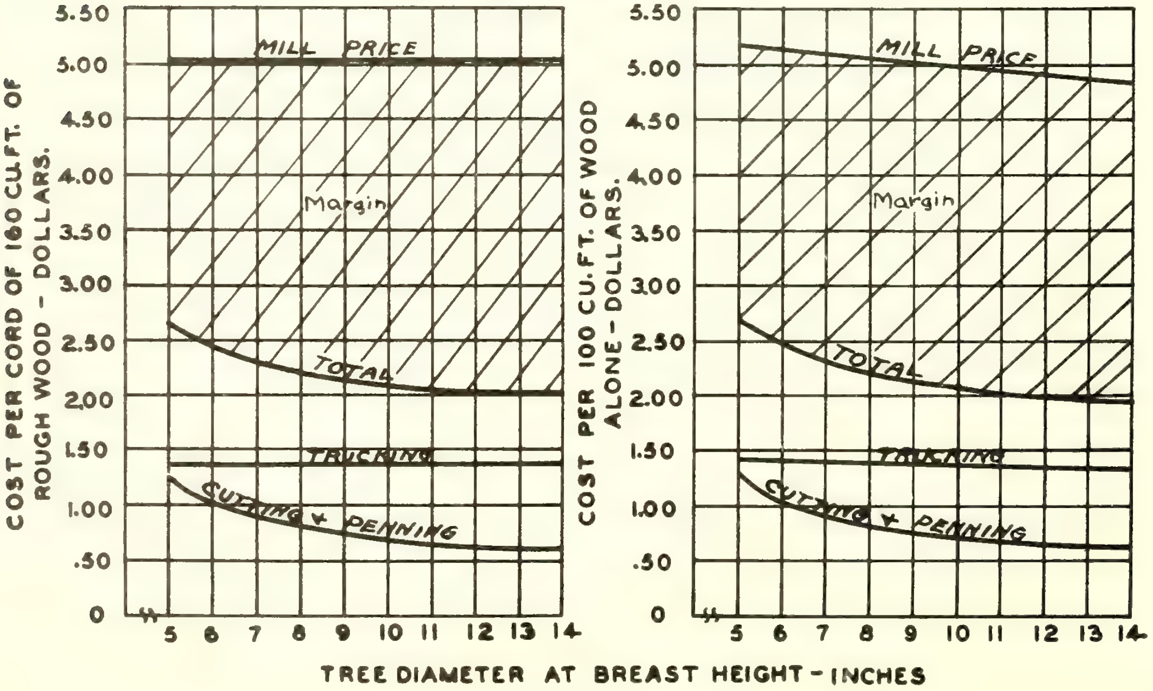
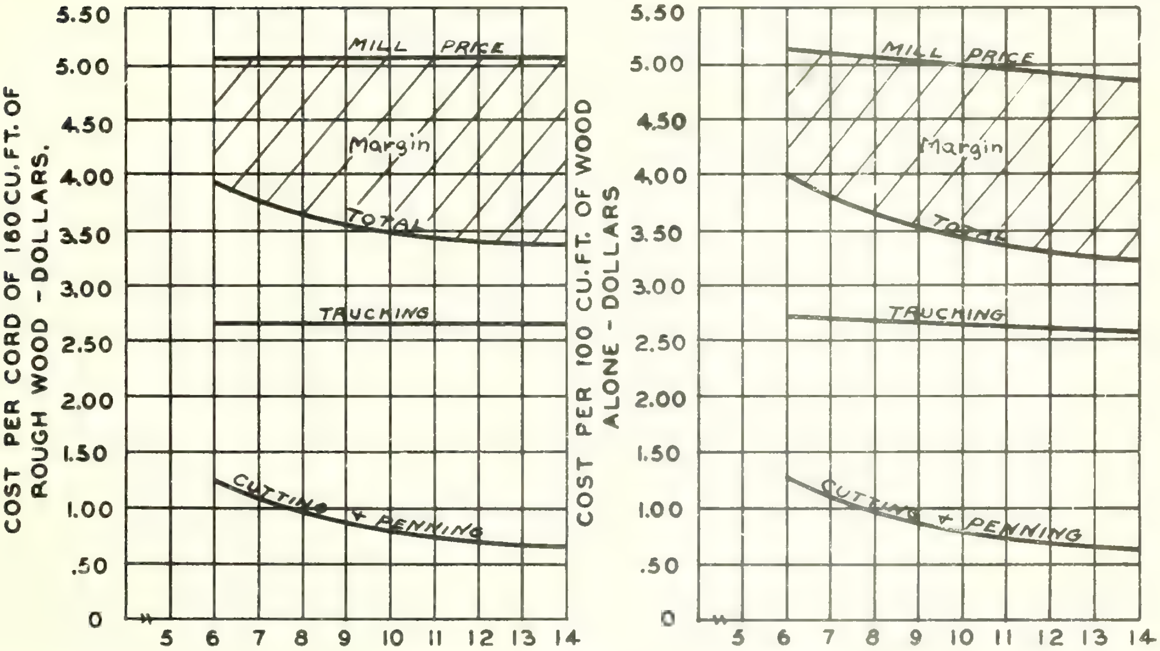


FIG. 4

SALES PRICE AND PRODUCTION COST OF PULPWOOD

CLASS II FOR TURPENTINED LONGLEAF PINE — ACTUAL CONDITIONS AS FOUND IN THE STUDY, TURPENTINED BOLTS TAKEN OR DISCARDED, TRIMMED OR NOT TRIMMED — BASED ON VOLUME ACTUALLY USED.

TRUCK-HAUL OF 26.1 MILES



TRUCK-HAUL OF 12.2 MILES

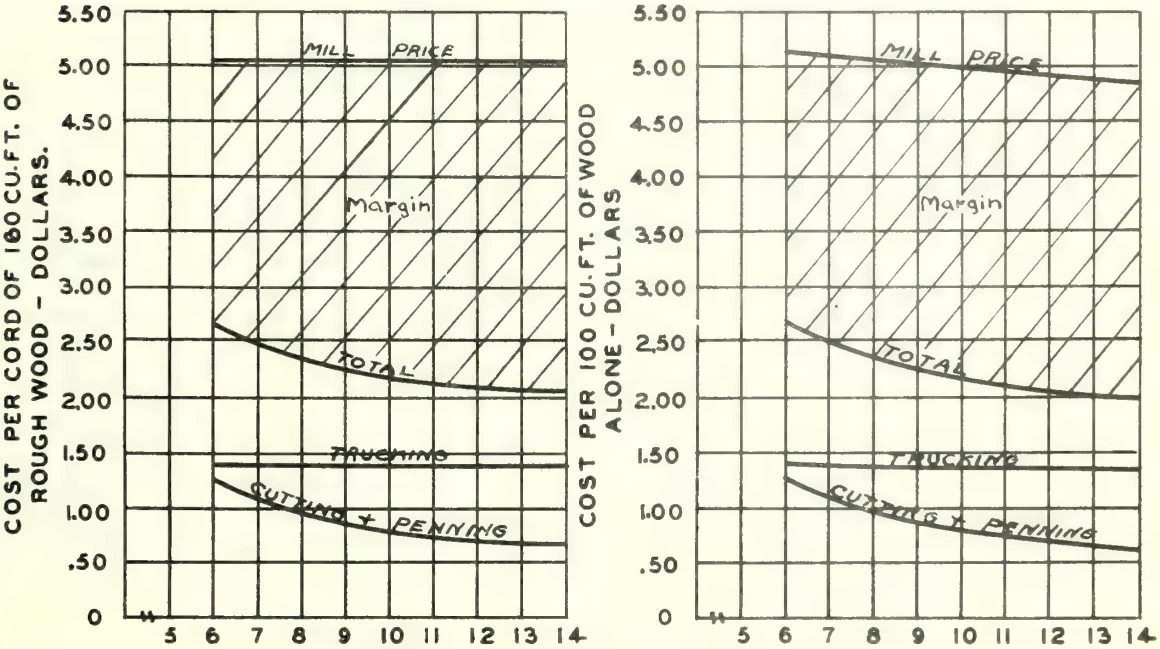
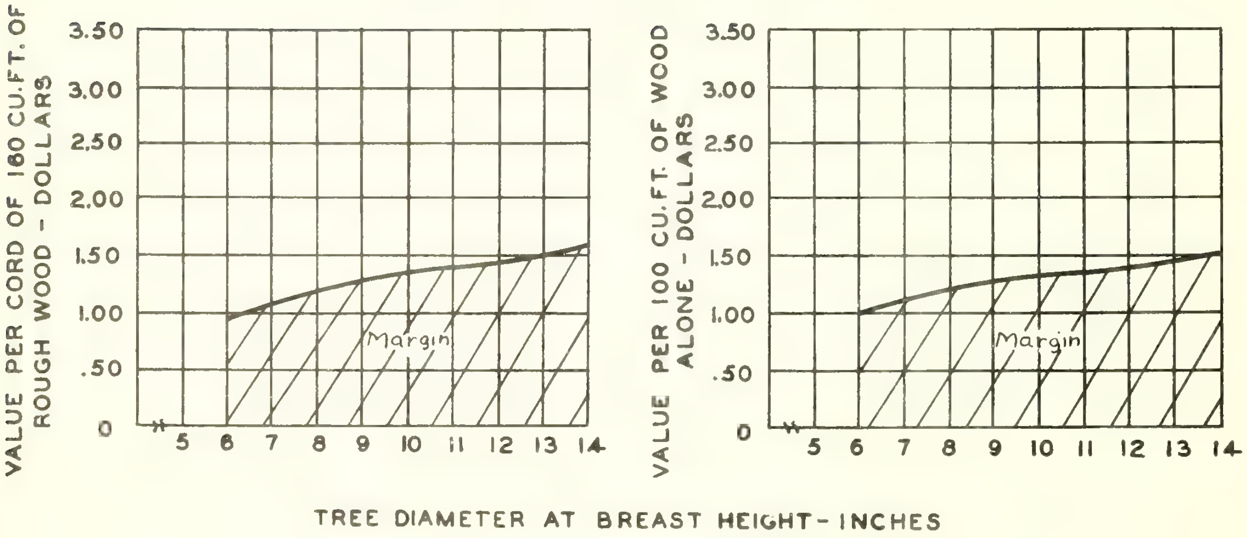


FIG. 5

MARGIN FOR RISK, PROFIT, AND STUMPAGE.

CLASS II FOR TURPENTINED LONGLEAF PINE - ACTUAL CONDITIONS AS FOUND IN THE STUDY, TURPENTINED BOLTS TAKEN OR DISCARDED, TRIMMED OR NOT TRIMMED - BASED ON VOLUME BETWEEN STUMP AND LAST CUT.

TRUCK-HAUL OF 26.1 MILES



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TRUCK-HAUL OF 12.2 MILES

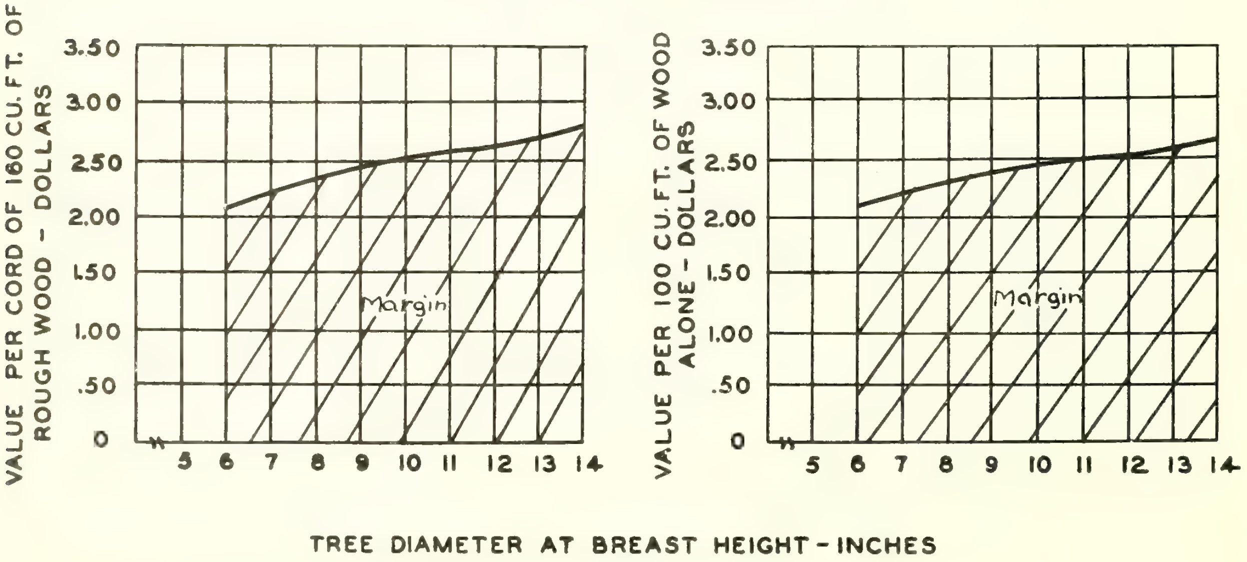

Table 12. - Estimated margin for profit, risk, and stumpage in pulpwood production per cord of 160 cubic feet of rough wood from longleaf pine

D.b.h.	For haul of 12.2 miles			For haul of 26.1 miles		
	Class I 1/	Class II 2/		Class I 1/	Class II 2/	
		Based on volume between stump and last cut	Based on volume utilized		Based on volume between stump and last cut	Based on volume utilized
Inches						
5	$2.38	-	-	$1.10	-	-
6	2.63	$2.05	$2.40	1.34	$0.95	$1.11
7	2.76	2.20	2.57	1.47	1.10	1.28
8	2.84	2.32	2.70	1.55	1.21	1.41
9	2.91	2.41	2.79	1.62	1.29	1.50
10	2.96	2.48	2.85	1.67	1.36	1.56
11	2.99	2.55	2.90	1.70	1.42	1.61
12	3.01	2.61	2.93	1.72	1.46	1.64
13	3.03	2.70	2.96	1.74	1.52	1.67
14	3.05	2.83	3.01	1.76	1.62	1.72

1/ Class I is defined on page 5.

2/ Class II is defined on page 5. The values in the first column under Class II are based on the wood and bark volume between stump and the last cut. The values in the second column under Class II are based on the volume actually used, that is the volume excluding those turpentined bolts which were discarded in pulpwood cutting. All data for cutting and hauling have been based upon the volume actually used. This is the first reference to potential pulpwood volume in the turpentined trees. From a landowner's viewpoint the values of the first column express the worth in the stand based on the volume actually present; from a pulpwood contractor's viewpoint the values of the second column express the worth of the stand based on what he might plan to cut under conditions similar to those of this study.

Sales price of pulpwood is $5.06 per cord of 160 cubic feet of rough wood - stacked volume.

Table 13. - Estimated margin for profit, risk, and stumpage in pulpwood production from longleaf pine; based on 100 cubic feet of wood without bark 1/

D.b.h.	Sales price 2/	For haul of 12.2 miles			For haul of 26.1 miles		
		Class I 3/	Class II 4/		Class I 3/	Class II 4/	
			Based on volume between stump and top	Based on volume utilized		Based on volume between stump and top	Based on volume utilized
Inches							
5	$5.18	$2.45	-	-	$1.13	-	-
6	5.14	2.68	$2.10	$2.45	1.37	$0.98	$1.14
7	5.10	2.78	2.22	2.59	1.48	1.11	1.29
8	5.07	2.84	2.32	2.70	1.56	1.22	1.42
9	5.03	2.89	2.39	2.77	1.61	1.29	1.49
10	4.99	2.91	2.44	2.81	1.63	1.33	1.53
11	4.96	2.92	2.49	2.83	1.66	1.38	1.57
12	4.92	2.91	2.53	2.84	1.66	1.42	1.59
13	4.89	2.91	2.61	2.86	1.67	1.48	1.62
14	4.85	2.91	2.70	2.87	1.67	1.53	1.63

1/ This table shows the data of table 12 on the basis of 100 cubic feet of wood without bark - solid volume.

2/ Sales price per 100 cubic feet of wood without bark when sale is made at $5.06 per cord of 160 cubic feet of rough wood - stacked volume. These values for each tree diameter class, are obtained by dividing $5.06, sales price per cord for rough wood delivered by truck by 1.144 - the converting factor from the cord of 160 cubic feet to 100 cubic feet of rough wood - solid volume; the result is then divided by the percentage of wood alone in wood and bark volume from table 3.

3/ Class I is defined on page 5.

4/ See footnote 2 of table 12.

Margin of Sales Price Above Production Cost

The average sales price of pulpwood delivered by truck to the pulpmill in this study was found to be $5.06 per cord of 160 cubic feet of rough wood stacked volume. (See left half of figures 3 and 4.) At a constant price per cord the mill pays more per cubic foot of solid volume for small-diameter wood than for large, because of the increasing percentage of bark volume in pulpwood as diameter decreases. This explains why the line labelled "mill price" slopes downward to the right in the right half of figures 3 and 4.

No compensation for risk and profit of the contractor[15] has been provided in the production costs presented in this report. There is but slight risk inherent in an enterprise of this nature. The amount of profit to which a pulpwood contractor is entitled is uncertain. For these reasons compensation for risk and profit is retained with stumpage in a lump sum called the margin of sales price above production cost.

Tables 12 and 13 show the margin of sales price above production cost for two units of volume, the cord of 160 cubic feet of rough wood and the unit of 100 cubic feet of wood without bark. Footnote 2 of table 12 explains the presentation of the two columns for Class II. These margins of tables 12 and 13 appear also in figures 3, 4, and 5. Figures 3 and 4 show them in the hachured area of the graphs between the mill price and the total cost curves. Figure 5 gives the margin based on the volume between stump and last cut for turpentined trees.

Pulpwood stumpage is commonly bought by the contractor for a lump sum for part or all of the stand of a specific area or is bought at a fixed rate per cord. Both methods of stumpage purchase were in use in the locality of this study. When pulpwood stumpage is purchased at a pre-determined price per cord, payment is customarily made as the contractor receives his pay from the purchasing mill and the mill's measurement of volume is accepted as the basis of settlement with the landowner. Pulpwood stumpage, when bought by the cord of 160 cubic feet of rough wood - mill measurement - ranged from 50 cents to $1.25 in the area studied. Variations in price were due both to relative location of the stumpage with respect to market and to the differences in bargaining power of buyer and seller as well as to quality of the timber. It is not possible to state what price was received by the landowner when a lump sum was paid for a specific amount of standing timber as no inventory was made of the available wood on any of these tracts.

If 20 percent of production cost be accepted for the purpose of discussion as the amount of compensation for risk and profit for the contractor, the following figures indicate the hypothetical stumpage value of the trees cut for pulpwood for the two operations where trucking costs were estimated:

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[15] The item of 5 percent of the average investment for uninsured risks in table 9 refers to risks peculiar to truck operation which could be cared for by taking out additional insurance.

Truck haul miles	Timber condition	Stumpage value per cord of 160 cubic feet of rough wood for each tree diameter at breast height									
		5	6	7	8	9	10	11	12	13	14
12.2	Class I 1/	$1.36	$2.14	$2.30	$2.40	$2.48	$2.54	$2.58	$2.60	$2.62	$2.65
	Class II 2/		1.60	1.77	1.91	2.02	2.10	2.17	2.23	2.31	2.44
26.1	Class I 1/	0.31	.60	.75	.85	.93	.99	1.03	1.05	1.08	1.10
	Class II 2/		.27	.45	.58	.68	.75	.81	.86	.90	.99

1/ Defined on page 5.

2/ Defined on page 5. Based on volume of rough wood between stump and last cut.

The wages recorded in this report were those current in the summer of 1934. However, with generally improved conditions wages may be increased. Such increases would directly affect stumpage values. If the piece-rate for pulpwood cutters were adjusted to enable them to earn $0.25 per hour and if truckmen were paid $0.30 per hour, the stumpage value per cord for the 12-mile haul would be a positive quantity for 7-inch trees and larger of Class I and for 8-inch trees and larger of Class II. The present mill price of $5.06 per cord precludes hauling pulpwood 26 miles under the assumed wage rates. It is estimated that the stumpage value of 13-inch trees of Class II would be minus $2.52 per cord for the 26-mile haul under these assumed wage rates The trees of smaller size would have still greater negative stumpage values.

The text table presented above shows the hypothetical stumpage values under certain specific operating conditions and under the assumption that 20 percent of production cost is a fair compensation to the contractor for risk and for profit. These values should not be confused with the cost of production of this stumpage. The costs and revenues of handling the stand have been ignored. The costs include such charges as taxes, fire protection, administration, thinnings and improvement cuttings. The revenues include such items as income from turpentining 16/ and material from thinnings and improvement cuttings and stumpage sold for such purposes as lumber, poles, piling, conduit blocks, and fuelwood. The value of stumpage which might be added by growth and financial increment (occurrin through rise of the price of wood products), as well as by possible enhanced growt of the portion of the stand which is left if partial cutting is practiced, has bee disregarded. For such reasons as these it is obviously impossible to indicate the size of the smallest tree profitable to handle on a forestry basis (from the viewpoint of the landowner who intends to devote the land in the future, as in the pas to the growing of forest products).

From a liquidation basis (from the viewpoint of the landowner who intends to "cash-in" on his timber and sell his land or allow it to "go" for taxes) all of the diameter classes listed in the foregoing text table show a positive stumpage value (based on the present mill price and current labor costs). If he is shrewd

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16/ It should be noted that the more progressive turpentine operators do not hang cups on young trees until their diameter at breast height has reached nine inches. Table 2, column 2, shows the distribution of turpentined timber by diameter classe encountered in the present study. It is very evident that many trees were turpen tined when but 5 and 6 inches in diameter.

enough to obtain these values in a sale - or an average price per unit of volume for his stand which would give him the same total price for his tract - all diameter classes from 5 to 14 inches should be included.

Analysis of Pulpwood Production Costs

A further analysis and grouping of the various items of cost in pulpwood production are included in the present report so that the present system may be better understood and possible ways of improvement suggested. Figure 2 shows the operation of pulpwood cutting under the following 4 parts: felling, limbing, bucking, and penning. The relative importance of these items for specified tree diameter classes is shown in table 14.

It can be seen in table 14 that the share of time and cost of cutting and penning chargeable[17/] to felling and limbing is relatively small except in the small tree diameter-classes. The major portion is chargeable to bucking (to trimming of fire-scarred turpentined bolts for Class II timber) and to penning. For example, in the 9-inch tree class, 22 percent for round trees and 23 percent for turpentined trees represent the portion of time and cost charged to felling and limbing, while the remainder, 78 and 77 percent respectively, is borne by the other pulpwood cutting operations. Between one-eighth and one-quarter of all cutting time and cost is attributable to penning. Pens (1) form the basis of payment for work performed; (2) serve as concentration points which decrease loading cost; (3) aid in reducing the amount of insect and fungus infestation through more rapid drying of pulpwood bolts; and (4) should serve to decrease hauling cost by the lessened weight of the partially dried wood per unit volume. It is not doubted that where factors (3) and (4) are regarded as unimportant, ways would be found to pay cutters on some other basis. Payment by the tree or by the individual bolt, regardless of size, ought to be satisfactory. The ease of tallying the output would not exist, however, under the bases proposed. It is obvious that loading pulpwood trucks from pens is faster than loading bolts as they lie on the ground after bucking. It is not known which method gives the lower total production cost under average conditions although it is believed that allowing bolts to remain on the ground until loading takes place is cheaper. Footnote 2 of table 10 shows the hourly truck-rate for the 12-mile haul to be $0.40 and for the 26-mile haul to be $0.36. The additional truck cost occasioned by loading bolts from their dispersed

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[17/] The assumption is made, which is by no means substantiated by observation, that all of these items of pulpwood cutting are equally laborious. It would appear that penning is the most tiring; bucking perhaps takes second place; with felling third; while trimming and limbing are the least exhausting of all.

Table 14. - Ratio of pulpwood cost items to the total cost, by tree diameter classes

Class I.1/ Pulpwood Timber

D.b.h.	Felling	Limbing	Felling & limbing	Bucking	Penning	Bucking & penning	Total of all cutting 2/		
(inches)	-	-	- Percent	-	-	-	Dollars	Man-hours	Percent
5	26	15	41	46	13	59	1.28	8.24	100
7	16	10	26	56	18	74	.91	5.84	100
9	13	9	22	56	18	78	.76	4.89	100
11	12	9	21	54	25	79	.68	4.37	100
13	12	9	21	53	26	79	.64	4.12	100

1/ Defined on page 5.
2/ Per cord of 160 cubic feet of rough wood.

Class II.1/ Pulpwood Timber

D.b.h.	Felling	Limbing	Felling & limbing	Bucking	Trimming turpentined bolts	Penning	Bucking, trimming & penning 2/	Total of all cutting 3/		
(inches)	-	-	-	-	Percent	-	-	Dollars	Man-hours	Percent
7	15	9	24	55	5	16	76	1.10	7.05	100
9	13	10	23	55	3	19	77	.88	5.66	100
11	12	10	22	54	2	22	78	.77	4.94	100
13	12	9	21	53	2	24	79	.71	4.52	100

1/ Defined on page 5.
2/ In the present investigation with seven of the eight crews studied, the decision whether to trim the turpentined bolt and include it in the output or to reject it, if unacceptable without treatment, rested with the cutters - see page 7 In the present report the time devoted to trimming of bolts rank as an unimportant item of total cutting and penning cost. This condition does not always exist. In another investigation, not yet reported, in similar timber where the landowner specified that all wood between a low stump and the top should be marketed, a sample of two days' cuttings of two-faced turpentined trees shows between 30 and 35 percent of cutting and penning time was spent reclaiming the fire-damaged portion of the turpentined bolts.
3/ Per cord of 160 cubic feet of rough wood based on volume actually used.

locations on the ground would have to be balanced against the man-hour rate for pulpwood cutters of $0.156 and the time required for the operation.[18]

It is shown in table 14 that for trees of the 7-inch diameter class and larger at least 70 percent of the cutters' time (and probably more than that proportion of his energy) is consumed in the items of bucking and penning. Bucking need not be done by hand-labor; it can be carried on with the proper power equipment in a suitable location. Penning is mainly a concentration process which could be efficiently performed with draught animals if the pulpwood were left in tree-lengths.

The data in tables 15 and 16 are presented to show for specified tree-diameter classes the relative importance of each item of production cost in terms of the total. It was shown on page 12 that pulpwood cutting is a hand-labor process where payment for labor comprises 83 percent of the cutting cost to the contractor. The remainder is spent by the cutters for tools and tool maintenance and by the contractor for supervision. In pulpwood truck operations one-third to one-fifth is spent for labor depending upon the length of haul. It is quite obvious that increase in pulpwood wages without accompanying increase in other items of cost would markedly increase cutting cost while trucking cost would not be so greatly affected. Thus it is well to give attention, if changes in methods are contemplated, to improvements which will require a smaller proportion of labor expense in relation to expenditures for equipment investment, maintenance and operation cost.

18/ Contractors would probably not make calculations of this type for their own work. It was stated (see page 6) that there is a difference between pulpwood cutting and transportation in method of payment. Usually cutting is paid for by a fixed piece-rate while trucking is performed by labor paid by the day working with trucks owned and operated by the contractor (or subcontractor). The contractor carefully watches for opportunities to reduce his transportation costs as lower costs in this department work to his immediate advantage. Cutting is "farmed-out" to individual cutting crews at a rather inflexible contract rate (for example, 20 cents per pen) and the contractor is loath to change a piece-rate once it is established. It is possible, however, to demand more in the form of additional labor for the same piece-rate in such instances as working less desirable timber or trimming a greater portion of fire-scarred turpentined bolts. To impose tasks or to assign timber for cutting which require 20 percent more time per unit of output is not resented as much as the equivalent reduction of 17 percent in the piece-rate. One does not readily think of units of measure as shifting but a change in price per unit volume is easily perceived.

While careful weighing of the cost of pulpwood production is quite possible the contractor is usually content to strive to reduce his transportation charges by penning even though the total production cost may be higher because of the expense to him (ultimately) of paying for penning.

Table 15. - Ratio of items of production cost per cord of 160 cubic feet of rough wood to total cost, by tree diameter-classes

Class I.[1] Pulpwood Timber

D.b.h. (Inches)	Length of truck haul - 12.2 miles - truckmen $0.118 per hour							
	Felling & limbing	Bucking & penning	All cutting	Loading and Unloading	Hauling	All trucking	Total of cutting and trucking	
	Percent						Dollars	Percent
5	20	28	48	9	43	52	2.67	100
7	10	30	40	10	50	60	2.30	100
9	8	27	35	11	54	65	2.15	100
11	7	26	33	12	55	67	2.07	100
13	6	25	31	12	57	69	2.03	100
	Length of truck haul - 26.1 miles - truckmen $0.108 per hour							
5	13	19	32	4	64	68	3.96	100
7	6	19	25	5	70	75	3.59	100
9	5	17	22	5	73	78	3.44	100
11	4	16	20	5	75	80	3.36	100
13	4	15	19	5	76	81	3.32	100

Table 16. - Ratio of items of production cost per cord of 160 cubic feet of rough wood to total cost, by tree diameter-classes

Class II.[1] Pulpwood Timber

D.b.h. (Inches)	Length of truck haul - 12.2 miles - truckmen - $0.118 per hour							
	Felling & limbing	Bucking, trimming and penning	All cutting	Loading and Unloading	Hauling	All truck-	Total of cutting and trucking	
	Percent						Dollars	Percent
7	11	33	44	10	46	56	2.49	100
9	9	30	39	10	51	61	2.28	100
11	8	28	36	11	53	64	2.16	100
13	7	27	34	11	55	66	2.10	100
	Length of truck haul - 26.1 miles - truckmen - $0.108 per hour							
7	7	22	29	4	67	71	3.78	100
9	6	19	25	5	70	75	3.57	100
11	4	18	22	5	73	78	3.45	100
13	4	17	21	5	74	79	3.39	100

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[1] Defined on page 5.

Competition of Pulp Industry With Pole Industry

Pole treating plants, to a certain extent, compete with pulpmills for raw material in the naval stores region. Any small pine tree is usually potential pulpwood timber; the demands of the pole treating plants are more exacting. For 10 million acres in southeastern Georgia, the Forest Survey, a project of the Southern Forest Experiment Station, estimated that 18 percent of the standing pines from 8 to 14 inches in diameter are potential pole material.

A questionnaire was sent to pole treating plants throughout the South in October 1936, asking for current pole prices by lengths and the American Standards Association classes. A summary of the 11 replies received is shown in table 17. Table 18 shows the corresponding values per 100 cubic feet of peeled wood, solid volume. It should be noted that these prices are f.o.b. cars at the loading point.

Table 17. - Prices for peeled pine poles f.o.b. cars at the loading point[1]

Pole length (feet)	American Standards Association Classes									
	1	2	3	4	5	6	7	8 [2]	9	10
					Dollars per pole					
16					0.42	0.34	0.30		0.29	0.24
18			0.59	0.58	.49	.40	.36		.32	.27
20	0.98	0.90	0.70	.66	.56	.46	.42		.36	.30
25	1.45	1.30	1.08	.90	.78	.65	.58		.50	.45
30	2.04	1.83	1.53	1.23	1.08	.93	.81		.72	
35	2.76	2.45	2.14	1.68	1.47	1.33	1.12			
40	3.64	3.20	2.84	2.32	2.04	1.80	1.52			
45	4.68	4.10	3.69	3.15	2.74	2.43	2.02			
50	5.95	5.20	4.80	4.20	3.70	3.30	2.70			
55	7.42	6.44	6.05	5.50	4.84	4.46				
60	9.06	7.92	7.44	7.02	6.18	5.88				
65	10.92	9.62	9.10	8.84	7.80					
70	12.95	11.55	10.92	10.92	9.59					
75	15.30	13.88	12.98	13.20						
80	18.00	16.56	15.28							
85	21.25	19.64	17.94							
90	26.10	23.49	21.06							

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[1] Based on 11 replies to a questionnaire sent to pole treating plants in the South.

[2] Prices for class 8 are not shown; data insufficient.

Table 18. Prices for peeled pine poles per 100 cubic feet - solid volume - f.o.b. cars at the loading point

Pole length (feet)	American Standards Association Classes									
	1	2	3	4	5	6	7	8 1/	9	10
	---------- Dollars per 100 cubic feet ----------									
16					9.90	9.33	10.13		11.52	12.00
18			8.61	9.76	9.72	9.43	10.59		11.57	11.25
20	7.60	8.74	8.24	9.30	9.33	9.02	9.77		10.00	10.34
25	8.06	8.84	8.74	8.65	8.71	8.55	9.13		9.62	10.71
30	8.79	9.34	9.16	8.66	9.00	9.30	9.76		10.75	
35	9.70	10.04	10.17	9.23	9.42	9.85	9.57			
40	10.61	10.85	11.14	10.50	10.63	10.71	10.41			
45	11.58	11.80	12.22	11.98	11.88	11.97	11.38			
50	12.66	12.94	13.71	13.73	13.65	13.69	12.68			
55	13.72	13.81	15.13	15.67	15.46	15.69				
60	14.43	14.80	16.32	17.64	17.41	17.98				
65	14.96	15.82	17.81	19.82	19.21					
70	15.42	16.81	19.12	22.02	21.22					
75	16.19	18.02	20.34	24.04						
80	16.89	19.23	21.64							
85	17.71	20.50	22.96							
90	19.25	21.99	24.49							

1/ Prices for class 8 are not shown; data insufficient.

Table 19. - Value of trees in table 1 by diameter classes which are suitable for poles

D.b.h.	Pole Class	Pole Length	Price 1/ per pole	Price per 2/ 100 cubic feet
Inches		Feet		
6	10	20	$0.30	$10.34
7	10	25	.45	10.71
8	9	25	.50	9.62
9	7	25	.58	9.13
10	7	35	1.12	9.57
11	7	40	1.52	10.41
12	7	45	2.02	11.38
13	6	40	1.80	10.71
14	5	45	2.74	11.88

1/ From table 17.
2/ From table 18.

The average used length and top diameter outside the bark is shown in table 1 for each 1-inch diameter class of the trees studied in this project. An estimate has been made of the class and length of pole which could be cut from trees of each diameter class if it were potential pole stock. This information is presented in table 19. The specifications and dimensions of the American Standards Association have been followed in making the estimates.

The prices per pole and per 100 cubic feet shown in table 19 for each diameter are prices f.o.b. cars at the loading point. Probably $1.00 per 100 cubic feet should be added to place the prices on the same basis as the mill price data for pulpwood shown in table 13, column 2. Timber is not so completely utilized for poles as when pulpwood is cut. However, pulpwood can be cut from the discarded butt of the pole tree and from the top providing this can be done at a profit.

The information is not at hand to estimate the production cost of poles for the various classes and lengths similar to that made for pulpwood in this report. Probably there is a wide variation in cost for the different sizes in the same operation.

IV. THE POSITION OF PULPWOOD AMONG THE FOREST PRODUCTS OF THE NAVAL STORES REGION

The naval stores region[19/] east of the Mississippi River covers a total land area of 50 million[20/] acres of which slightly more than 36 million acres, 72 percent, is classed as productive forest land. Table 20 presents data showing production[21/] of certain forest products in 1934 with an estimate of the value based on 1936 prices. According to these data the gross income from sale of naval stores, about 27 million dollars, is 49 percent of the total income from the forest products listed. Pine lumber[22/] production ranks second with an estimated value of 44 percent of the total. The other items listed; namely, pulpwood, poles and piling and railroad ties are of lesser importance, ranking in the order named. The value of pulpwood is 3 percent of the total and about equals the value of the other minor products.

These volumes and gross values of finished forest products do not answer the question of the relative ranking of forest products in terms of income to the landowner in the form of stumpage. The latter part of table 20 shows the relative stumpage income. From the total estimated stumpage income in 1934 of about 12 million dollars, lumber leads with 6 million dollars (50 percent), naval stores is second with 5-1/3 million dollars (44 percent), pulpwood a poor third with 1/3 million dollars, (3 percent), while poles and piling and ties account for a little less than 1/2 million dollars between them (2 and 1 percent of the total respectively). This estimate of 12 million dollars stumpage income for the naval stores region is at the rate of $0.34 per acre.

[19/] See map figure No. 6.

[20/] See page 2 "Statistics on Gum Naval Stores Production," Forest Survey Release No. 17, Southern Forest Experiment Station, December 31, 1935.

[21/] From unpublished Forest Survey data.

[22/] Production of cypress and hardwood lumber is not included.

Table 20. - Current volume and value of forest products of the active naval stores region

Forest product	Unit of Measure	Production in 1934	1936 price per unit	Value of 1934 production using 1936 unit price	Proportion of total value	Estimated stumpage value 5/	Proportion of total estimated stumpage
					Percent		Percent
Naval stores	Unit 1/	3/ 535,161	4/ $49.85	$26,677,776	49	$5,335,555	44
Pine lumber	M. bd.ft.	1,039,340	23.00	23,904,820	44	5,976,205	50
Pulpwood	Cord 2/	437,000	4.00	1,748,000	3	349,600	3
Poles and piling	Lineal feet	17,989,000	.05	899,450	2	269,835	2
Ties	Piece	2,008,000	.40	803,200	2	160,640	1
				$54,033,246	100	$12,091,835	100

1/ 1 barrel (50-gallon) of turpentine and 3-1/3 barrels of rosin.
2/ Standard cord (128 cu.ft.).
3/ For naval stores season 1934-1935 (year ending March 31, 1935).
4/ Season average price April-September, 1936, inclusive.
5/ Based on: 20 percent of 1936 price for naval stores
25 percent of 1936 price for lumber
20 percent of 1936 price for pulpwood
30 percent of 1936 price for poles and piling
20 percent of 1936 price for ties.

Such income[23] for an area made up largely of second-growth pine under present unmanaged conditions implies relatively good returns for well-managed tracts and better income for the whole area whenever common-sense management measures are more generally adopted.

Such management would provide for the following:

(1) Fire control to assure natural reproduction and to prevent injury to reproduction, saplings and turpentined trees.

(2) Building up of understocked stands by holding the cut below the growth and especially building up the larger diameter classes so that as much as possible of productivity of the site is devoted to growth of merchantable trees.

(3) Light and frequent cutting in order to shift growth from trees of poor form and vigor to better trees.

(4) Holding the better quality trees until financially mature for turpentining, sawtimber or other use.

(5) Utilization of each portion of the tree and of each tree for its highest value in order to net the greatest profit.

The production of pulpwood in the naval stores region in 1936 will greatly exceed that recorded for 1934. Pole and piling production will also be greater. It is reasonable to believe that pulpwood in the future will rank higher with respect to lumber and naval stores than at present. It is unlikely that the supremacy of the latter will ever be seriously challenged by pulpwood. Figure 1 (page 2) indicates a subordinate place for pulpwood in most schemes of management of pine stands in the naval stores region. Only a serious disruption of the present balance of prices of timber, naval stores, pulpwood, ties and poles and piling will bring about a coordinate position for pulpwood with the 2 major forest products of this region.

The map in figure 6 points to one issue which concerns treating plant men mainly but is of obvious concern also to sawmill and naval stores operators. It is noted that pulpmills are often being built in the vicinity of established treating plants. In this area, due to unstable conditions of forest ownership and to the desire to "cash-in" on present pine stands, much of the pulpwood is produced by clear cutting, usually in timber which has been worked for naval stores, but occasionally in timber which has never been cupped. Wholesale cutting for pulpwood means that potential pole-timber and potential saw-timber are going into pulpwood without full consideration of the best interests of the landowner and of the community at large.

There is much to be said in explanation of the present situation in regard to pulpwood cutting. A pulpmill is built with capital from outside the region, operated by men usually unfamiliar with woods conditions, and run to capacity because of a favorable combination of low stumpage and cheap woods labor. Technical advances in the last 2 decades have made possible the use of southern pine for pulp and the first mills in a given territory usually reap good profits.

From the forest landowner's standpoint the coming of a pulpwood market is very advantageous. Raw material for which there has been no previous demand becomes salable. Of course sawtimber continues in demand and the pole men continue to hunt the choicest trees for treating plants. Much timber is too small for sawlogs (even with the low standards prevailing for portable mills) and the

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[23] If the higher value stumpage is being removed faster than it is growing, an unknown amount of this "income" must be regarded as a charge against the investment.

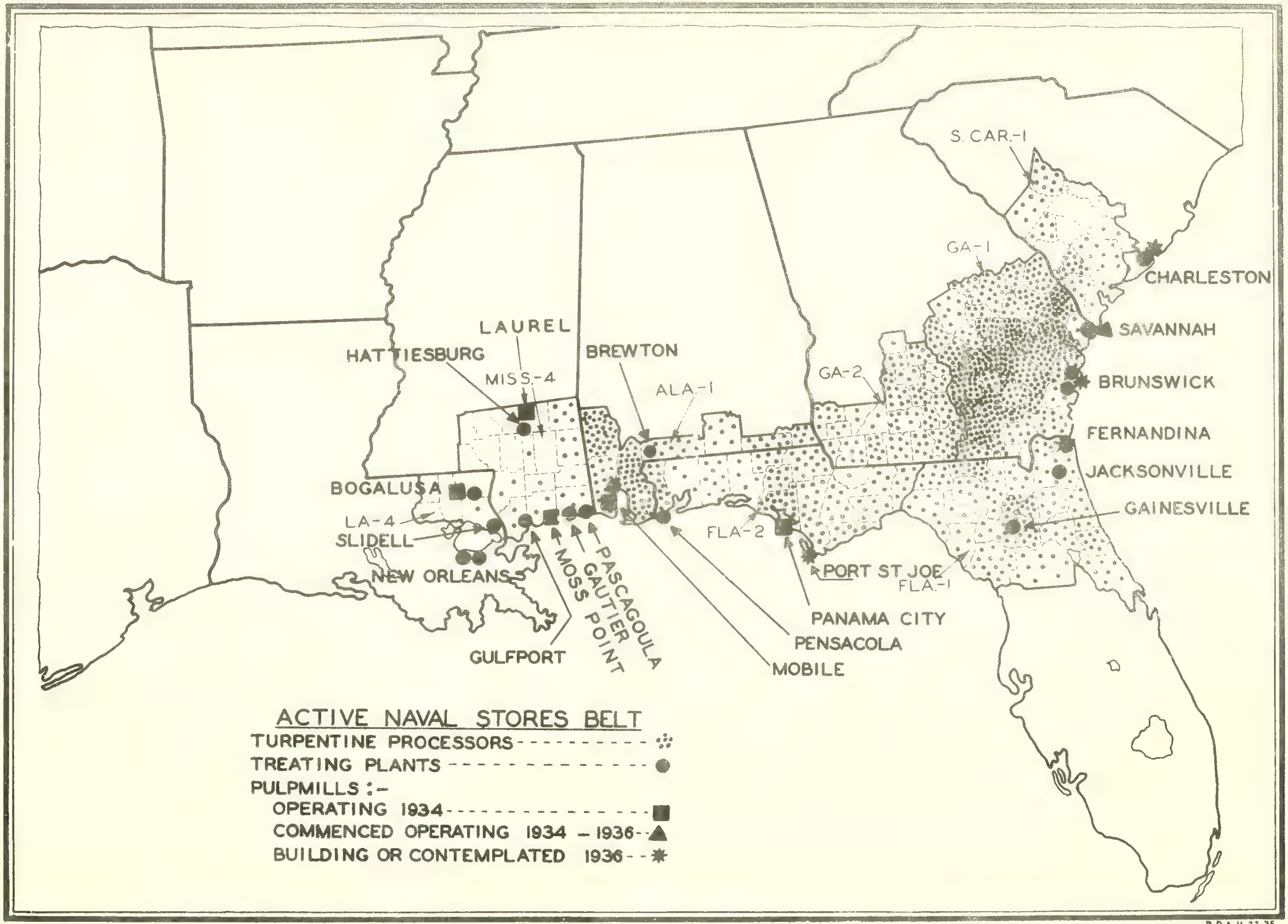

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FIG. 6

treating plant demands are noted for their sporadic character.[24]

Pulpmills supply a commodity uniform in character whose demand is fairly steady. Pulpmills, for low costs, must operate continuously and to "comfortable capacity." They therefore demand a relatively steady supply of raw material. This condition in turn enables a pulpwood contractor to build up an organization gauged to maintain a stable output. The pulpmill usually divides its raw material territory between contractors so the landowner can deal with but one buyer for his stumpage. The owner either sells to him or not at all. The contractor is mainly interested in taking as much wood as possible from a given tract, either in turn for a lump sum for the whole area or for an agreed price per cord based on the volume delivered to the mill. Cutting restrictions would hamper the contractor and seem unconsequential to a landowner who usually has his timber because of the bounty of Nature.

Even if data were available to the landowner as to how best to handle his timber land to obtain the largest returns over the ensuing generation, a steady moderate income does not have the appeal of a larger amount offered in a lump sum. It is reasonable to believe that measures to conserve timber and promote continuous forest production will come from the users of forest materials rather than from the landowners. The stake of the pulp plant owner in continuous forest production is large.

V. SUGGESTED CHANGES IN PULPWOOD PRODUCTION METHODS

Various ingenious schemes have been proposed to save pole-timber from the pulpwood contractor. Many have merit but they all necessitate foresight, patience, technical organization, and ready capital on the part of the treating plant owner, landowner, or pole contractor. More resources are demanded than there is much possibility of supplying. The schemes suggest such measures as "storing on the stump"[25] meaning the outright purchase by the treating plant operator of a pole supply for a number of years ahead. It has also been suggested that the pole man secure options on potential pole stock. This plan has merit but landowners prefer a lump sum of lesser size now, than a greater sum in the future. A stumpage price of $1 a cord for pulpwood in 2 months time is greatly preferred over a $0.20 a cord option now with the prospect of final sale several years hence at $2, $3, or even $4.

Another plan is proposed here. This plan would call for a new type of logging contractor. He would replace the pole-man, the pulpwood man and possibly the portable mill man. He would have to be a business man to a far greater degree than his predecessors. He would need more equipment, more working capital, and an organized personnel of greater capabilities than heretofore.

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[24] Treating plant men claim that they cannot operate steadily because of the indefinite character of their orders from power, telephone and telegraph companies. They say that they are given a fair idea of the number of poles for an ensuing year in their contracts but they have no knowledge of the lengths and American Standards Association classes which will be ordered during the contract period. A state construction and maintenance superintendent of a large telephone company in reply to the question of why pole demands could not be specified by lengths and sizes stated that in his opinion they could be within a reasonable margin of error but that the purchasing organization did not ask for data of this nature.

[25] Lemieux, Frank J. "Forestry in Southern Pines Is Here to Stay" page 98 k, vol. 153, No. 1937, Southern Lumberman, December 15, 1936.

Under the proposed plan the pulpmill procedure would not be changed. The mill would continue, as at present, to need cheap wood with delivery guaranteed. The mill would continue to buy its wood in cordwood lengths of 4 to 5 feet. Treating plant procedure would be changed because it could no longer operate at the convenience of the power, telephone and telegraph companies. Its customers would be required more nearly to make up their year's requirements at the beginning of the contract period so that the treating plants might pass on the orders to the new type contractor by pole-classes and lengths. Of course stabilized production in the treating business and stabilized work in pole production would have the effect of producing treated poles at less cost.

The Plan in Brief

Under the proposed plan, the logging contractor would arrange contracts with the pulpmill, the nearby treating plant, and local saw-mills (unless he is a saw-mill operator himself). Next he would contract with landowners to remove all or a designated part of the timber on certain parts of their holdings. The plan would work equally well under clean or partial cuttings, a matter to be determined by the forest owner.

The heart of the contractor's operating set-up would be his concentration or cut-up plant to which he would bring the logs in tree lengths. [26] By means of mechanical devices, all of which are in use in wood utilization plants in the South, the tree-length sticks can be moved about, sorted and cut into the products which will bring the greatest income to the plant operator. The important individual in this plant is the man who sizes up each tree-length and decides how it should be cut. He will be called the "marker" in this discussion; quite properly he might operate some of the machinery. Specifically the proposed cut-up plant may be built up from a well-designed combination of a "Starr" unloader, a reversible conveyor with power "niggers" at convenient stations to divert the different products from the conveyor trough to other conveyors or to storage. A power cut-off saw, perhaps a circular saw of the swinging type, would work satisfactorily. A central plant would furnish power to operate the unloader, conveyors, "niggers" and cut-off saw. The marker could readily control the operation of the main conveyor and the cut-off saw.

The logging contractor would carefully weigh his available markets and the prices therein; he would have to make the most of his purchased raw material. Possibly if there were trees of the required dimensions a small saw-mill of his own would be advisable to work in conjunction with his plant. Perhaps he could induce some small saw-mill operator to locate with him or he might make arrangements to ship his logs to an established sawmill in the vicinity. In certain localities conduit blocks or slack stave blocks might bring better prices than pulpwood.

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[26] A cut-up plant handling tree-length timber has been in operation at the Superior Pine Products Company of Fargo, Georgia. Poles, logs, conduit blocks and pulpwood were cut from the timber.

The essence of this plan is careful inspection and selection of the run-of-the-woods timber. Conceivably the marker might wander about in the woods and pass judgment on each tree as it stands or as it lies after felling. Perhaps in some cases this is the better course. However, there is no opportunity under such a system to rid the operation of its more complex character. Pulpwood would have to be bucked into 4-5 foot lengths by hand labor as heretofore. Poles and logs would occur in lengths from 12 to 60 or 70 feet. It is obvious that pulpwood trucks, log trucks and pole trucks would have to be provided and they are not readily interchangeable. Pulpwood would require loading by hand as at present. If the tree lengths were brought to a central point intact, equipment might be standardized at a minimum and supervision could be correspondingly reduced. It is obvious that passing the tree-lengths one-by-one past a marker who also operates the cut-up machinery would insure the opportunity for the maximum of scrutiny for possible enhanced returns from proper sub-division of the tree-lengths. Hand labor could be reduced to a minimum and probably production costs would be materially lowered.

The major part of woods production cost lies in the transportation element. Under the system proposed, hand labor would be confined to felling, limbing and making the top-cut of the timber to be removed from the stand. Where the forest is accessible to trucks with a minimum of road building - typical of the naval stores region - the bunching of truck loads of timber could be done for relatively short distances with teams or light tractors. Loading may be done with a number of devices ranging in order of investment from the customary cross-haul with teams to truck-or tractor-mounted swinging booms of the dragline type. Trucks and trailers hauling tree-lengths as long as 70 feet are at present successfully operating in the naval stores region. It is evident that the selection of equipment is a matter for the contractor who has all factors to consider in making his choice.

VI. SUMMARY

The following conclusions can be drawn from this investigation of pulpwood production in the naval stores region:

1. The contract system of production was employed. The woods requirements of the mill were supplied by a selected and limited number of contractors. Each of these directly supervised production or sublet a portion or all of his quota to lesser contractors. The cutting and penning of pulpwood was done by piece-work. Trucking was usually performed by day labor.

2. A maximum of hand labor was used in production. Time of cutting and penning decreased per unit of volume with increase of tree size. Round trees 5 inches in diameter required 8.24 man-hours per cord of 160 cubic feet of rough wood compared with 3.99 man-hours for trees 14 inches in diameter. By applying the average hourly wage to these man-hour requirements the cost including supervision was $1.28 compared with $0.62. These data were based on the average output and average earnings of eight pairs of cutters. Corresponding values for worked-out turpentined trees were slightly higher.

3. The earnings of pulpwood cutters averaged $0.13 per hour. On an hourly basis the wages of truck men averaged slightly less.

4. The major share of pulpwood production costs was incurred in transportation. Under certain assumptions the transportation costs was about the same for pulpwood from trees of all sizes. For one operation with a 12-mile truck haul to the mill, transportation charges were $1.39 per cord of 160 cubic feet or 52 percent of production cost for round trees 5 inches in diameter and 69 percent for trees 14 inches in diameter. For another operation with a 26-mile haul, transportation charges were $2.15 per cord of 160 cubic feet of rough wood or 68 and 81 percent for trees of 5 and 14 inches, respectively.

5. The mill price for pulpwood was $5.06 per cord of 160 cubic feet of rough wood. The margin for profit, risk and stumpage was $2.38 per cord for round trees 5 inches in diameter and $3.05 for 14-inch trees for the 12-mile haul; for the 26 mile haul corresponding values were $1.10 and $1.76.

6. In the naval stores region, lumber and naval stores are the major forest products and are likely to continue so. Pulpwood cutting is causing concern among pole men for their future supply of timber.

7. It is possible that a portion of the raw material now being cut into pulpwood could be used more advantageously for poles or other products. A plan is proposed which would permit the utilization of all portions of each tree to the best advantage.

PLATE I

PULPWOOD PRODUCTION

A. Turpentined stand of longleaf pine after being cut for pulpwood. The timber was cupped when 5-7 inches in diameter. Cupped trees and also uncupped trees to a small diameter limit were removed. (F.S. Neg. 303892.)

B. Pulpwood cutting in 60-year old longleaf pine. Only trees worked out for turpentine have been cut. The residual stand is left for further growth and eventual turpentining. Note the pens of pulpwood. (F.S. Neg. 303883.)

C. Before the pulpwood was cut the area in this picture was covered by a stand of shortleaf and loblolly pine; the ownership boundary is marked by the line of cutting. One side is clear cut and the other left untouched. (F.S. Neg. 204762.)

D. Pulpwood cutters in the naval stores region. Both white and colored men work at pulpwood cutting. (F.S. Neg. 303874.)

E. Most kraft paper mills accept turpentined butts if all charred wood and metal have been removed. Some landowners require that all these butts be salvaged. If fire has not charred the turpentined faces only ingrown bark and nails need be removed. (F.S. Neg. 303881.)

A

B

C

D

E
303881

PLATE II

PULPWOOD TRANSPORTATION

A. Loading car from a pulpwood truck in the shortleaf-loblolly-pine-hardwood type. Pulpwood production is largely performed by hand labor. (F.S. Neg. 303634.)

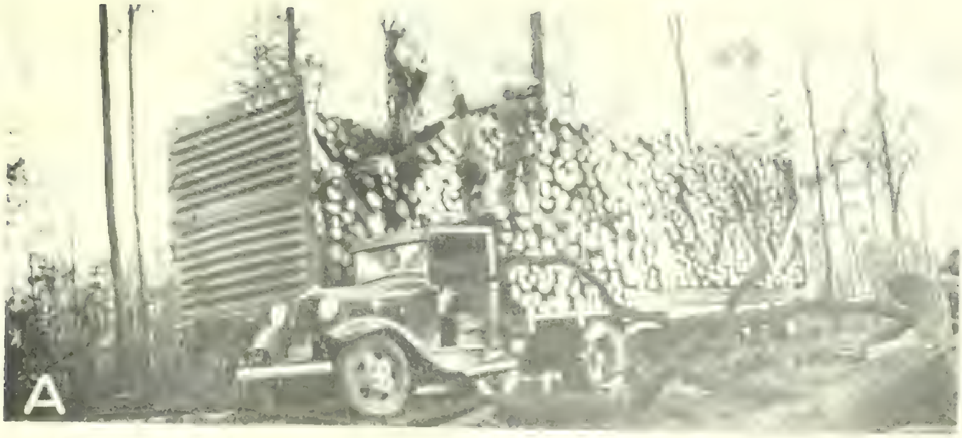
B. Loaded barges ready for the tow to the pulpmill. A large proportion of the wood supplied pulpmills in the naval stores region arrives by barge. (F.S. Neg. 303463.)

SCENES OF POLE PRODUCTION AND LOGGING IN THE NAVAL STORES REGION

C. Peeling poles in a longleaf pine stand. Poles, logs, and pulpwood, in the order named, are removed from his timber land by this operator. (F.S. Neg. 332735.)

D. Loading small poles with a "cross-haul." The rejected poles, in bottom of the load, are taken to the sawmill unpeeled for conversion into lumber. (F.S. Neg. 332733.)

E. Logs as long as 30 feet are hauled by trucks and trailers in the naval stores region. The trucks can travel through most of the area with a minimum of road preparation. (F.S. Neg. 332731.)


A

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OCCASIONAL PAPER No. 59 February 23, 1937

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

ECONOMICS OF OUR SOUTHERN FORESTS

By

E. L. Demmon

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

ECONOMICS OF OUR SOUTHERN FORESTS [1]

By E. L. Demmon, Director,
Southern Forest Experiment Station,
New Orleans, La.

This paper will point out briefly the part played in the general economy by the forests of the South, and the opportunity they offer to bring about a greater measure of prosperity to this section of the country. The importance of forests to Florida will be indicated by some of the data presented.

Viewed from the angle of land area involved, the forests of the South are more important than the agricultural lands. The Southern Forest Experiment Station, a regional forest research unit of the United States Forest Service, has recently completed a field inventory of the forest resources on an area of 216 million acres. Including those portions of South Carolina and Arkansas not covered by the Survey, the gross land area in the lower South totals nearly 237 million acres. [2] Of this latter area, 60 percent or slightly more than 140 million acres, is forest land. Although exact data are not yet available as to how much timber is standing on this vast domain, we know that it represents a resource of immense value. Furthermore, it is a resource that, under proper management, will renew itself, and indeed is capable of yielding greater volumes of forest products in the future than it has in the past. Any general study of the economy of the South cannot overlook the part which this forest empire can and should play. As a matter of fact, the total value of the forest land, timber, and forest-products utilization plants in the South is conservatively estimated at nearly 2 billion dollars.

As a source of tax revenue, it is estimated that the South's forest land and timber represents nearly 10 percent of the assessed valuation of all property — real and personal, rural and urban. This forest land and timber was assessed in 1935 at about $450,000,000, or the equivalent of $3.21 per acre. Unfortunately, not all this assessment yields a tax revenue, owing to widespread tax delinquency which has resulted in the nominal forfeiture for unpaid taxes (in 1934) of some 17 million acres of forest land, out of a total of over 31 million acres of all delinquent lands in this region. The situation in Florida in respect to tax default is more serious than in any other southern State. In 1934, there were in tax default for 3 or more years over 12 million acres, or more than one-third of the gross land area of the State. Of this area, approximately 8 million acres were forest land.

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[1] Address delivered at the Rollins College Economic Conference, Winter Park, Florida, February 2, 1937.

[2] In this discussion, the Southern States referred to include South Carolina, Florida, Georgia, Alabama, Mississippi, Louisiana, Arkansas, eastern Texas, and southeastern Oklahoma (timbered portions of latter 2 States).

Measured by value of products, southern forest industries rank high. According to the latest United States Census figures, the value of all products derived from southern forests including lumber and timber, cooperage, wooden boxes, naval stores, wood distillates, charcoal, pulpwood, etc., amounted (in 1933) to $185,000,000, or 8 percent of the value of all manufactured products of this region. The value of forest products for the years since 1933 will undoubtedly show a substantial increase. Only as recently as 1929, the value of manufactured forest products in these 9 southern States totalled approximately $600,000,000.

The labor requirements of the forest industries have, of course, declined somewhat with the falling off in production during the recent depression. Nevertheless, in 1934, the production of commercial forest products in the part of this region recently covered by our forest survey (216 million acres) required the equivalent of full-time labor of about 122,000 men in the woods and 87,000 men in the plants, or a total of 209,000 men. The actual number of individuals employed was considerably more than this number, as many are employed only part time in these industries. Assuming 4 persons to a family, about 836,000 persons were directly dependent on the forest industries in these States during 1934. These figures just given refer only to commercial products derived directly from the forest. In addition, it is estimated that the equivalent of full-time labor for 150,000 men is required annually in producing fuelwood, fence posts, and other products used on farms, obtained by farmers from their own woodlands. The distribution of the commercial labor among the major forest industries is shown in the following table:

ESTIMATED FULL-TIME LABOR REQUIREMENTS OF FOREST INDUSTRIES IN ALL OR PORTIONS OF EIGHT SOUTHERN STATES -- 1934 1/

Commercial products	Number of full-time laborers2/			Man-days labor per unit of product	
	Woods	Mill	Total	Man-days	Unit
Lumber	33,220	59,230	92,450	3.00	MBF (Int.¼-inch rule
Veneer	4,612	4,828	9,440	3.68	" " " " "
Cooperage	2,917	3,877	6,794	3.64	" " " " "
Miscellaneous	1,842	2,514	4,356	6.58	" " " " "
Naval stores	43,120	2,600	45,720	660.	Crop (10,000 faces)
Cross ties3/	11,453	-	11,453	.14	Tie
Poles and piling	1,548	-	1,548	.176	Piece
Treating plants	-	3,155	3,155	19.00	M cu. ft.
Pulpwood	7,761	10,435	18,196	3.22	Cord
Fuelwood4/	15,932	-	15,932	1.52	"
Total commercial	122,405	86,639	209,044		

1/ Includes Alabama, Florida, Georgia, Louisiana, Mississippi, southeastern South Carolina, eastern and southern Arkansas, and east Texas.

2/ Based on 200 working days per year, the average for these industries.

3/ Includes some commercial fence posts.

4/ In addition to this item, the labor used in cutting fuelwood and other forest products used on the farm is equivalent to full-time employment for approximately 150,000 men.

Comparing forest-products industries with all other industries, the most recent Census figures (1933) indicate that the forest industries employed 22 percent of all industrial wage-earners in these nine States, and paid 14 percent of all industrial wages.

I have covered briefly the present place of our forests in the industrial economy of the South. Now, as to some of the future possibilities:

It has been prophesied - we foresters have said it ourselves at various times in the past - that within 10 or 20 years, or some similarly brief period, most of the commercial timber in the South would be gone, and with it would disappear the industries dependent upon it. That statement was true for certain limited areas, but fortunately it did not hold for the South as a whole. The prophesies did not take into account the marvelous recuperative powers of our southern cut-over forest lands, influenced as they are by soil and climatic conditions exceptionally favorable to forest growth. Illustrations can be found, of course, of devastated southern forest lands, of ghost towns resulting from the abandonment of the large lumber mills. These ghost towns stand as monuments to overcapitalization of timber holdings, to liquidation of timber assets, brought about by the rapid growth of the Nation as well as by other factors, and to lack of responsibility of stewardship over this great natural resource. But Nature has been kind to the South, and over great areas is now producing for us and for our children a new crop of timber which, if properly managed, will support most of our present forest industries, and many new units, in perpetuity.

Let me elaborate briefly on some of these future possibilities, particularly for the gum naval-stores industry and for the recently expanding pulp and paper industry. Florida has a special interest in gum naval stores, of which it produces about 30 percent of the total in the South, and in pulp mills, with the largest mill in operation in the South (Paname City) and two projected mills (Fernandina and Port St. Joe).

The United States for more than a century has been the world's largest producer of turpentine and rosin. This naval-stores industry in normal years represents an annual output of approximately $50,000,000 worth of products. These products are of basic importance to the Nation as they are used in the manufacture of paint, varnish, linoleum, paper, soap, ink, grease, synthetic camphor, and many other articles. A recent Forest Service survey shows that the naval-stores belt embraces an area of approximately 34 million acres of land on which longleaf and slash pines predominate. These two native species of pine are the only trees of importance in the commercial production of naval stores in this country. From this area come all of the gum and turpentine and rosin produced in the United States, and a large part (68.5 percent in 1930-31) of the entire world's production of these commodities. About one-half of the United States naval-stores production is exported.

In this naval-stores belt, our recent survey reveals that there are approximately eighteen hundred million (1,800,000,000) longleaf and slash pine trees 2 inches or more in diameter which have not been worked for naval stores. Most of these (1,225,000,000 trees) are under 6 inches in diamter. It is calculated, however, that sufficient trees will reach turpentining size (8 to 9 inches in diameter) each year to permit 24 million new trees to be brought into turpentining annually if the owners dedicate them to that use. This annual increase offers a fair index of the sustained-yield possibility of this region for naval stores. In order to obtain continuous production of naval stores, it is necessary to add to the body of working trees each year a sufficient number of new faces (the chipped areas on the trees, from which the gum flows) on round (unturpentined) trees to offset the shrinkage due to mortality and the abandonment of worked-out trees. In the naval-stores belt as a whole, the ratio that this annual replacement bears to the total working body of faces approximates 1 to 8-1/3. Applying this ratio to the indicated annual income of 24 million new faces on fresh trees, it is estimated that a working body of 200 million faces (20,000 crops of 10,000 faces each) can be maintained in continuous production. Such an operation would, at current average yields, produce 800,000 units [1] of naval stores, as contrasted with the present average production of 500,000 units. Expressed in more common terms, it is possible to increase the annual production of gum turpentine by 300,000 barrels, and the annual production of gum rosin by 1 million round barrels.

This rough appraisal of the future possibilities in the naval stores industry is based upon a consideration of the naval-stores belt as a whole and on the assumption that all longleaf and slash pine trees would be worked for turpentine before cutting them for any other use. If any considerable numer of trees were cut for pulpwood before reaching turpentine size or were kept unturpentined, to be made into poles, piling, lumber, or ties, potential naval-stores production would be correspondingly reduced.

Some of you may recognize the implication in these figures on potential naval-stores production. The naval-stores industry today could follow no surer and speedier road to bankruptcy than to produce 800,000 units a year. For the past several years, consumption has barely kept up with production, and each year until 1936 the carry over has increased. Financial distress in the industry has been acute. Hence, while the South's forest resources would permit a considerable expansion in this industry, such development should await vastly improved demand by present consumers, and the development of new uses and new markets. Meanwhile, under the Agricultural Conservation Program, the naval-stores operators are retracting rather than expanding. Over 14 million turpentine faces were taken out of production after this program was initiated in July 1936, in an effort to reduce anticipated overproduction. This action, along with adverse climatic factors, reduced production for the season to about 90 percent of normal; and prices, particularly of rosin, have shown substantial increases.

A naval-stores conservation program for 1937 has recently been announced by the Secretary of Agriculture with $1,400,000 set up for benefit payments. A feature of the new program for those who desire to accept its terms will be the requirement that conservative woods practices be used, including the prohibition of operating trees under 9 inches in diameter, or of placing more than one turpentine face on trees less than 14 inches in diameter. Another provision is that turpentine streaks shall not exceed 3/4 inches in depth nor more than an average of ½ inch in height. Furthermore, applicants must agree to provide fire protection to the land being worked, whether it is owned, leased, or otherwise controlled. Payments for compliance with this program, i.e., for reducing production, will be

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[1] One unit of naval stores equals one 50-gallon barrel of turpentine and three and one-third barrels of rosin of 500-pounds (gross) each.

1¢ per face for turpentine faces remaining in operation during the 1937 season, and 4¢ per face for not turpentining trees under 9 inches in diameter which were worked in 1936 or discontinued under the 1936 program.

Within recent years, increasing attention has been given to the possibilities of expanding the pulp and paper industry in the South. At present, the South dominates the field in the production of pulpwood where the sulphate process is used, the principal products being kraft wrapping paper, bags, and boxboards. In 1934, there were 16 pulp mills in the southern States making kraft paper, with a daily capacity of about 3,400 tons.

Within the past year, several new kraft pulp and paper mills have been under construction in the South, and the total daily capacity of these mills, with others that have been announced but on which construction is not yet under way, amounts to over 3,600 tons of pulp; the investment in these new plants amounts to about $65,000,000. These mills are designed primarily to produce kraft paper, although at least two of them will produce bleached sulphate which will go into high-quality white paper. As yet, no southern mill has been erected for the production of newsprint. A recent news item, however, states that the mill at Port St. Joe, Florida, has plans for an annex where commercial development of newsprint from southern pine pulp will be carried on. A plant in Texas to produce newsprint is also contemplated.

Approximately 55 percent of our domestic pulp and paper needs are now imported, chiefly from Canada and the Scandinavian countries costing us over $150,000,000 annually. The present annual consumption of pulpwood equivalents in the United States is approximately 14 million cords. A possible total future national requirement of 25 million cords annually can be used as a basis for estimating the contribution which the different forest sections of the United States can make in supplying this need and still conserve the Nation's forests.

Assuming complete dependence on domestic supplies to fill national requirements, a recent Forest Service report 1/ indicated that the South could be expected to supply 7-1/2 million (30 percent) of the 25 million cords required in the future, or more than any other single forest region of the country, including Alaska. It is further estimated on the same basis that the South can provide 2 million (30 percent) of the 6.6 million cords of newsprint required, 2 million (17 percent) of the 11.9 million cords of mechanical and sulphite pulp, 3.2 million (64 percent) of the 5 million cords of sulphate pulp, and 0.3 million (20 percent) of the 1.5 million cords of soda pulp. This estimate for the South is based on the assumption that the present installed production capacity for each process (chiefly sulphate in the South at present) would be maintained. Beyond this limit, prospective production was distributed with regard to relative accessibility, quantity of standing timber, current and theoretical future annual growth, suitability of species for the various processes of manufacture, and other pertinent factors. Those familiar with the pulp and paper possibilities in the South feel that this estimate is very conservative, especially in view of recent developments in chemical processes in the manufacture of newsprint from southern pines.

1/ National Pulp and Paper Requirements in Relation to Forest Conservation, Senate Document 115, 74th Congress, 1st Session, July 1935.

Among the factors which should be considered in the location of pulp mills are: (1) Availability of an ample and continuous supply of good-quality pulping cordwood, (2) labor supply, (3) power and fuel, (4) water, (5) chemical supplies, (6) transportation facilities, (7) proximity to markets, and (8) taxes, etc. The South has an advantage in low transportation costs from woods to mill and from mill to market. In 1928, the average cost in the United States of transporting a cord of pulpwood from forest to mill was $3.23; in the South it averaged $2.00 a cord. Low water rates on pulp from southern ports to New York and other northern centers, coupled with low production costs, permit the southern pulp manufacturer to deliver his product to these consuming centers at extremely low prices compared with those for pulp from other regions.

Since wood is the most important single item of pulp cost, the South, because of its present and potential supply of timber, is particularly well situated to attract the newsprint and other paper industries. Studies made of standing cordwood volume in pulping species in specific areas in the South indicate that the South has for immediate conversion at least 250 million cords, making due allowance for the demands of other wood-using industries. This includes the volume in all trees over 5 inches in diameter at breast height which are of pulping species, and hence does not represent the volume now actually available for conversion into pulp. Growth conditions for this growing stock, however, fall far short of optimum. Furthermore, our best estimates indicate that, averaging all forest land together, even with the present incomplete stocking, the annual growth is around one-third cord per acre per year. At this rate, on the 140 million acres of southern forest land there are now being produced about 47 million cords annually. Approximately three-fourths of this growth is in pulping species, or a total of approximately 35 million cords.

Under intensive forest management on the better forest sites, and with an adequate growing stock, an average growth of 1 cord or more per acre-year can be expected. There should be no difficulty in obtaining pulpwood of suitable size and quality for many paper products from any one of a great many localities in the South. Abundant low-priced raw materials, rapid tree growth, easy logging conditions, an ample supply of good water, relatively low labor costs, and favorable freight differentials to northern markets, form a combination of factors assuring that the South will play a prominent role in supplying the United States with a large proportion of its future paper requirements.

Although the prospects of a successful expansion of the pulp and paper industry in the South are full of promise, certain precautions must be observed if this expansion is to be permanent. In our opinion the following policies should govern this expansion:

1. There should be no greater installation of paper mills than the South can support from timber not needed for established forest-using industries.

2. Insofar as economic circumstances will permit, new pulp mills should be fairly well distributed throughout the region and not concentrated in restricted localities.

3. Each plant should be planned for permanency and should utilize the timber in its territory on a sustained-yield basis with full regard for the needs of other wood-using industries, integrating the production of pulpwood with other forest products of greater unit value.

In the lumber industry, the picture is somewhat different, although by no means as dark as was predicted a few years ago. It is true that most of the original pine and hardwood has been converted into lumber and other forest products. The harvesting of this original timber crop was an important step in the progress of the settlement of the Nation. In many cases, the method of that conversion was destructive and wasteful, although not all of the blame is to be laid at the door of the lumber industry. Nevertheless, on most of the cut-over forest lands in the South today is a second-growth stand of timber which, if properly managed, will support a large forest industry forever. The character of the forest industries in the future, however, will not be the same as in the past. The day of the big mills, with daily capacities of 80,000 or more board feet, is already rapidly drawing to a close. Their place is being taken by smaller mills having a daily capacity of 40,000 feet or less. There are some exceptions to this trend, of course, particularly in the more favorable timber-growing locations in the South. Here large mills can be operated indefinitely, if sustained-yield forestry is practiced. Some operations will undoubtedly be placed on this basis as soon as the opportunities for financial rewards become more evident.

Thus far I have discussed only the future of the industrial use of the forest. There are, we should all recognize, other important uses of the forests. In the past, little attention has been paid by southern farmers to the values inherent in their farm woodlands. To be sure, several million dollars' worth of forest products are cut each year from these woodlands, some of which are sold and others used at home or in interfarm trade. Today more than half of all farm land in the South is in woodland, exceeding by 5 million acres the total area in agricultural crops. Too little attention, however, has been given to conserving the forest values through judicious management of these farm woodlands. Although farmers cannot carry on work in the woods the entire year, they can add considerably to their present and future incomes by taking a few simple forestry measures, such as protecting their woods against fire and overgrazing, by cutting their fuelwood from overmature, suppressed, and defective trees, by thinning young stands to promote more rapid growth of desirable trees, and by "shopping around" to get the best prices for their stumpage or for forest products they cut themselves.

In yet another field, forests play an important role in the economy of the South. Their part in conserving soil, in preventing erosion, and in ameliorating flood conditions is not always recognized. The Southern Forest Experiment Station is conducting intensive field research in vegetative control of erosion, and on the effect of forest and other plant cover on run-off of rain water. Our studies thus far indicate that forests have an important regulatory influence on streamflow and ground water, and serve effectively to prevent soil wastage and flood damage.

The range livestock industry offers another example of the opportunity of using forest lands for purposes other than the production of timber. Most of the South's forest land provides some grazing for livestock. This industry contributes an important share of the income and subsistence of southern farmers. It falls far short, however, of even supplying local market needs. Climate and soil conditions are favorable to a marked expansion in the livestock industry on southern forest ranges.

Forests are destined to become even more important in the future for recreation and the production of game. There is a marked trend toward the setting up by public agencies of game refuges and breeding grounds for wild life, where game will be produced under scientific management, and hunting permits will be issued to sportsmen at periodic intervals. On one national forest in the South, the income from such hunting licenses alone last year was $500.00, at a price of $5.00 per license. On another, where it was desired to reduce drastically the game population, more than 3,000 applications were received, of which only 1,700 were granted, these hunters paying $5.00 each for the privilege. On the same national forest, fishing brought in another $1,000, with licenses costing $1.00 per day.

Although this discussion thus far has dealt mainly with the South on a regional basis, a few figures will be included to indicate the importance of forests to Florida.

The forest survey recently completed by the U. S. Forest Service indicates that there are about 23,356,000 acres of forest land in Florida; this represents about two-thirds of the total land area of the State. Some 3,000,000 acres of this area, however, are classed as non-productive. Some of the balance may also be submarginal for timber growing at the present time.

Of the productive forest area covered by the survey, 78 percent is dominated by pines (on 92 percent of the pine land, longleaf and slash pines predominate), 15 percent by hardwoods, and 7 percent by cypress. Of the entire productive forest area, 15 percent is in old growth, 60 percent in second-growth of all sizes and 25 percent clear-cut.

It is estimated that the total board-foot volume of merchantable timber standing in 1934 was slightly over 24 billion feet (International 1/4-inch scale), of which approximately 90 percent is now merchantable. Of this merchantable volume, 57 percent was in pine, 25 percent in hardwoods, and 18 percent in cypress. In addition to sawtimber materials, there were almost 80 million cords of wood in smaller trees (from 5 inches in diameter to sawlog size), tops of sawlog-size trees and in culls, including all species of wood.

During the same year (1934) it is estimated that the forest industries in the State cut approximately 1.1 billion board feet and 328,000 cords of material for all purposes, including that used on farms.

By the beginning of 1936 the total estimated growing stock of sawlog material had dropped to 26-3/4 billion board feet. The annual increment during that year is estimated at about 710 million board feet; while the annual cut was about 1.5 billion board feet or more than twice the growth. This left a growing stock as of January 1, 1937, of about 22 billion board feet.

In 1934, there were a total of 912 lumber, veneer, and cooperage plants, turpentine stills, and other forest-utilization plants providing employment to the equivalent of 42,635 laborers in the woods and in the plants.

These figures on Florida are preliminary and subject to further change but are sufficiently accurate to give a picture of the current forest situation in the State. As additional forest land is brought under fire protection (at present about 2 million acres of private land and 1½ million acres of national forest and resettlement areas are being protected), and with the adoption of conservative forestry practices, growth and drain could be brought into balance. This will be necessary if Florida is to make full use of the forest land which makes up such a great proportion of its total area.

To conclude, let me briefly summarize the place of forestry in the future of the South. Private forestry can be practiced and be made to pay. One of the best means of assuring a profit from forest lands is to make them serve many uses. One of the primary requisites is that only the annual production or "interest" be removed each year and that the capital stock or "principal" be conserved. On the National Forests, "multiple-use forestry" is the accepted policy of management. If we are to have sustained-yield private forestry, it also must take into account such a policy of management.

To illustrate, assume a 50,000-acre forest in northeastern Florida fairly well stocked with second-growth longleaf and slash pines, typical of many such areas to be found in that region. The first task under a well-organized forest-management program is to secure adequate protection against uncontrolled fires. Such protection can usually be arranged in cooperation with the State forestry organization and with neighboring forest-land owners. An inventory of the timber resources and a determination of the growth rate is necessary. Certain trees can then be selected as best suited for a final crop of high-grade sawlogs. These trees would be reserved for this purpose, and the future management of the forest would be designed to produce in them the very highest quality of lumber. A portion of the remaining stand could then be turpentined conservatively, leaving the trees under 9 inches in diameter for future working, unless it may be desirable to remove some of the smaller trees to favor the growth of the better ones. Such thinnings would improve the growth and quality of the remaining stand, and could find a ready market at the nearest pulp mill. Certain other trees, if of suitable size and quality, could be cut for poles, piling, and railroad ties, and their tops and limbwood used for pulpwood. Game could be introduced into the area and could be increased with proper management, the annual production of game being taken off by leasing the hunting privileges. Some grazing could also be practised, if it did not interfere with the primary purpose of producing timber. This is what is known as multiple-use, sustained-yield forestry, where lumber, naval stores, pulpwood, poles, ties, livestock, and game are being produced on a permanent, continuous basis. The annual yield per acre from all these products, assuming intensive and efficient management, should be made to yield a substantial profit on the original investment. A recent study indicates that a net return per acre of 94¢ is possible at the present time, if such multiple use were adopted.

That is the goal, multiplied many times over, that we have in mind for the forests of the South. Its realization will bring about permanent employment of labor, permanent industries, permanent communities, more prosperous railroads and other utilities, stable and broad tax bases, and a better standard of living for this section of the country. It is estimated that our southern forests can supply direct, permanent employment at living wages to at least 500,000 workers, thereby providing a living for 2 million people. This presents a different picture from the one of forest exploitation and community abandonment that has been so common in the past. It may not be too much to say that the wise development and use of its forest resources is the key to the economic and social betterment of Florida and of the other Southern States. Many public agencies, including the State forestry organizations and the United States Forest Service, are working to promote a fuller use of the South's forest resources, many of which are now but partially utilized. The final result is largely up to the private owners in whose hands over 90 percent of these forest lands are held. The rewards should well repay their best efforts.

* * *

OCCASIONAL PAPER No. 60 April 10, 1937

DULL CHIPPING TOOLS CAUSE FIFTEEN PERCENT LOSS IN GUM YIELD

By Truman E. Pease, Superintendent,
Olustee Experimental Forest,
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It has long been realized that sharp chipping tools are important for good naval stores practice. Wyman and Coulter in "Florida Naval Stores," Florida Forest Service, Bulletin No. 9, July 1933, point out that high yields are obtained from even, regular streaks made with sharp tools. Although most operators realize that it is desirable to use sharp tools so that clean rather than bruised streaks are made, it is doubtful if they are aware of the large yield difference which results.

Several operations were canvassed to note the actual condition of the hacks used by chippers. Chippers' intentions are invariably good in regard to using sharp tools, but some apparently do not realize the length of time tools remain sharp. Most of the chippers sharpen their hacks when first starting work, again after the noon hour, and occasionally during the day, according to the hardness of the timber in which they work. A few sharpen their hacks at the first of the week and do not touch them again for a day or so. Experience has taught the older chippers the additional advantage of using sharp tools, to make their work easier, but this is not true of the younger chippers.

In the summer of 1934 the Southern Forest Experiment Station initiated an experiment on its Olustee Experimental Forest in north Florida to determine the effect of sharp and dull hacks on gum yield. The dull hack used was one which had become dull through use and which had not been sharpened (but allowed to become even duller) during the course of the experiment. The sharp hack was one used on the regular chipping experiments and was consistently kept sharp.

Twenty trees of approximately the same diameter and growth rate were selected for study. These trees were chipped uniformly with the same sharp hack for 9 weeks during which time yields were recorded individually for each tree. At the end of the 9-week period the trees were placed into 2 groups of equal yielding capacity, an "A" group and a "B" group. For 7 weeks during the fall, group "A" was then chipped with the sharp tool, and group "B" with the dull tool. Beginning again in April 1935, the treatments were reversed and for 7 weeks group "B" was chipped with the sharp tool and group "A" with the dull tool. Three more reversals were made at intervals of 10 weeks, 8 weeks, and 5 weeks, respectively. The study was discontinued after each group had received 5 treatments with sharp hack and 5 treatments with dull hack.

Gum yields were analyzed taking into consideration the temperature on the day of chipping, the number of weeks since chipping began, and the character of the tool. Figure 1 shows the "A" group yields and "B" group yields, plotted over the number of weeks since the inauguration of chipping after differences due to temperature were allowed for in the Statistical analysis of the data.

It will be noted from this chart that when the "A" group was chipped with a sharp hack and the "B" group with a dull hack, the "A" group yields were consistently higher than those of the "B" group. This is shown by the difference between "A" group yields and "B" group yields, as the sharp and dull tools are reversed for the various periods. These differences can be readily followed on the curves. The times at which the tools were reversed are indicated.

To obtain the effect of a dull tool on yields the difference between the sharp-group yields and the dull-group yields was computed as a percentage of the sharp-group yields. For the entire 1½ years' work the dull tool averaged 15 percent less yield than the sharp tool.

Simple percentage differences in gum yield, however, do not tell the whole story. A reduction in yield is not only reflected in the total output of the operator, but it also results in a considerable increase in the cost of production per unit. The result is, therefore, a double loss. A hypothetical example will illustrate the economic principle involved.

Since the seeling price, as well as practically all of the costs of production of turpentine and rosin, fluctuates continually, no set of costs would be applicable for any considerable length of time. For purposes of illustration, however, this is not so serious, because the same principles apply and the changes are only in degree, Therefore figures applying at any particular time give at least a good indication of the effect of improved practices on profit or loss. For this reason in the following example use is made of figures presented by Wyman and Coulter in "Florida Naval Stores," Bulletin No. 9, page 45, table IV.

Operators working a 40-unit crop will get only 34 unit barrels if it is worked with a dull hack, i.e., a reduction of 15 percent from 40 units. The costs for dipping, scraping, hauling, and still operation are the same whether 34 or 40 units are produced, assuming that the operator produces enough or does sufficient custom stilling so that his still is kept running at capacity. His fixed costs, such as hanging, chipping, lease, interest, depreciation, etc., are charges that he must pay on each crop worked regardless of the yield. Therefore the cost per unit varies with the number of units produced. The following table shows the returns per crop using a dull and a sharp tool.

Yields, Costs, and Differences in Profit
From Sharp and From Dull Tools (1929 Costs and Selling Prices)

Tool used	Yield per crop	Per-unit costs dependent on yield	Per-unit costs[1] independent of yield	Total cost per unit	Selling price per unit	Profit per unit
	Units	Dollars	Dollars	Dollars	Dollars	Dollars
Sharp	40	15.87	40.49	56.36	67.82	11.46
Dull	34	15.87	44.61	60.48	67.82	7.34
				Loss due to dull tool:		4.12

1/ Includes cost of selling.

Thus with prices prevailing in 1929 a turpentine operation of 10 crops capable of yielding 40 units per crop would make 400 units at a profit of $11.46 per unit or a total profit of $4,584.00. The same place using a dull tool would make only 340 units at a profit of $7.34 per unit or a total of $2,495.60. A net loss of $2,088.40 would, therefore, be directly chargeable to dull hacks. With present lower prices an even greater loss would occur.

An alert operator must, therefore, be particular in seeing that his chippers use sharp hacks constantly, so that they make clean-cut rather than haggled streaks.

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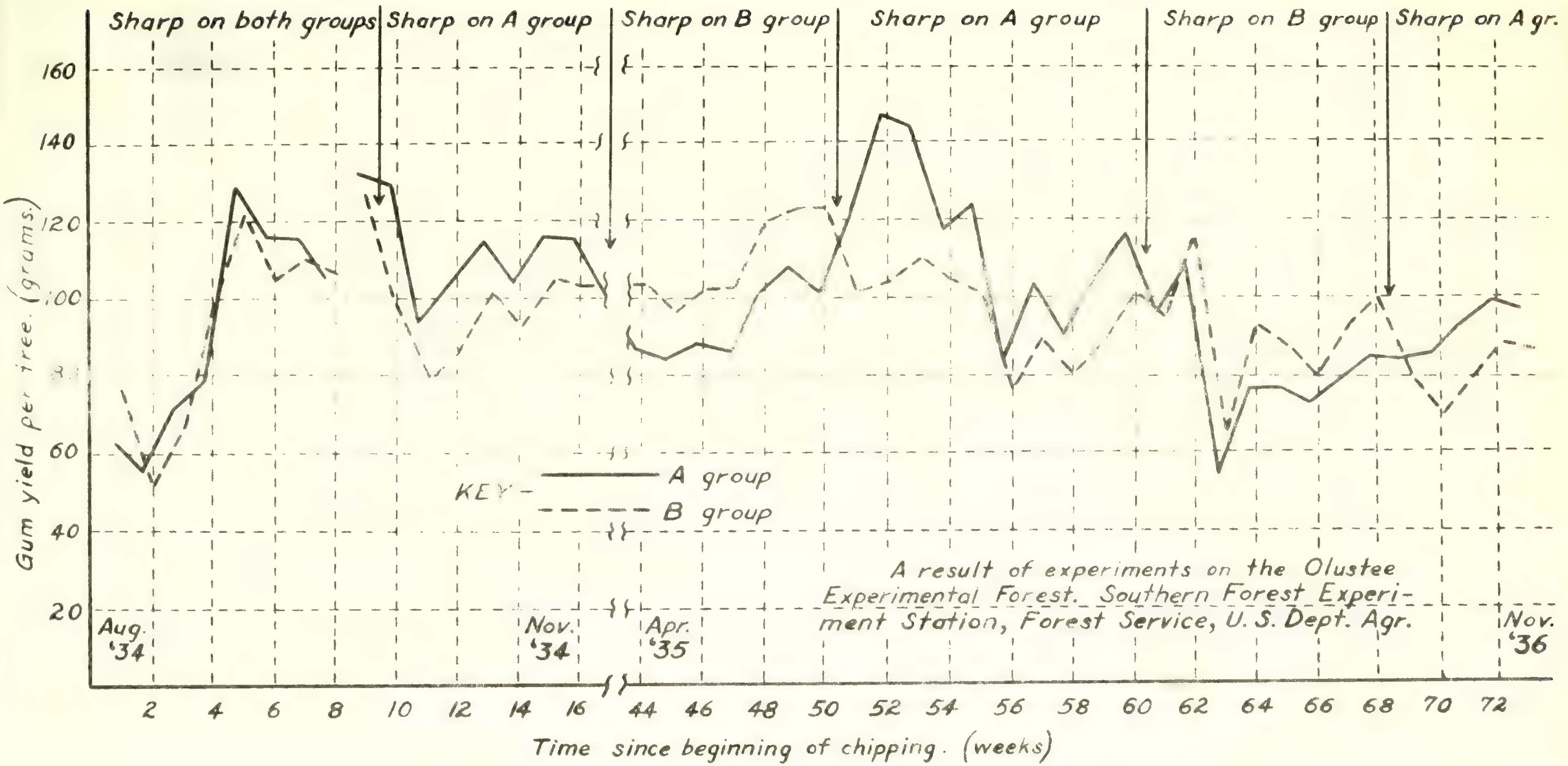

Figure 1. – The effect on the yield of gum of chipping with a dull vs. sharp hack.

NAVAL-STORES YIELDS FROM BARK-BARS

By
T. A. Liefeld, Assistant Silviculturist
Southern Forest Experiment Station

Bark-bars, the vertical strips of unchipped wood between two turpentined faces, are of great interest to naval-stores men. They are frequently referred to as life-bars because of their influence on the gum-yielding capacity of faces, and because of the marked effect they have on the rate of face healing and general vigor of the tree. This portion of the tree usually increases in rate of growth after turpentining begins. If a bark-bar is severed, the expanse of uninterrupted, chipped surface approximately doubles; this usually results in the face becoming partially unproductive owing to the development of "dry face."

Bark-bars 15 inches or more in width (if indeed they can be called bark-bars when this wide) are required to support an 8- or 9-inch face, the size usually considered workable in commercial practice. The bark-bars on the ordinary back-faced tree will attain this width only after a long resting period, in spite of a possible increase in growth rate, because of the smallness of the tree at the start of turpentining. The fact that the trees are small is evidenced by the large number of second-growth trees under sawlog size which, from the standpoint of naval-stores production, are now classed as worked-out trees. Whether the wider of the bark-bars--for instance, those 8 to 10 inches wide--can be worked profitably for naval stores is a question frequently asked.

The financial possibilities of working bark-bars, of course, depend largely upon the gum yield. With information as to yield, an operator can determine, for his own particular operation, the minimum width of bark-bar that is likely to be profitable. To fill this need a study was undertaken in 1935 by the Southern Forest Experiment Station, and the results of work during 2 years are reported in this paper.

The experimental area, comprising about 40 acres in the Osceola National Forest, near Olustee, Fla., located well within the active naval-stores belt, is representative of many worked-out, abandoned naval-stores areas. Prior to purchase by the Government, frequent fires and heavy chipping had resulted in an open and irregularly spaced stand. Most of the trees were old-growth longleaf pines 65 to 100 years old. A few old-growth slash pines in addition to scattered second-growth longleaf and slash pines made up the remainder of the stand. The age of the second-growth averaged about 40 years. The slash pines included a higher proportion of second-growth trees than did the longleaf.

A total of 360 trees ranging from 6.5 to 14 inches in diameter at 10 feet above the ground was originally selected, numbered, and measured, but a severe wind and lightning storm reduced this to 342 trees during the first season of chipping. During the second season this total was reduced to 340 trees. All of the trees had at least two worked-out faces. Bark-bars ranged from 7 to 28 inches in width, and the faces placed on these bars ranged from 3 to 9 inches in width. On each tree only one bark-bar was worked, usually the largest available. Galvanized cups were hung, and aprons and gutters were inserted in shallow ax cuts. A streak ½-inch high and ½-deep was chipped each week from early April to late October of each year, making 32 streaks for the season. The chipping was closely supervised to insure adherence to the specifications for face widths and streaks. Cups were dipped after every four streaks and the gum from each tree was weighed; scrape was weighed at the end of the season. The solid-line curves in figure 1, for a total of 342 trees as noted above, are based on 281 American-faced trees plus 61 French-faced trees, although the yields of the latter are not discussed in this paper. Similarly in figure 2 the solid-line curves are based on 279 American-faced trees plus the 61 French-faced trees,[1] making a total of 340.

The analysis of the yield data showed that the most important factors influencing the yield of gum from bark-bars were (1) width of face, (2) diameter of tree, and (3) width of bark-bars at the sides of the working face (subsequently referred to as secondary bark-bars). Other factors that were studied--(1) growth rate of turpentined bark-bar, (2) width of unturpentined bark-bar or bars remaining, and (3) tree vigor, as measured by the proportion of the total height in live crown--exerted only a minor influence on the gum yield and are therefore omitted from further discussion.

Figure 1 shows for the first year of work the net effects on gum yield of the factors (1) face width (1-A), (2) diameter of tree (1-B), and (3) width of secondary bark-bars (1-C). Each curve shows the influence on the yield exerted by the single factor in question with the other two factors held constant. Figure 1-A shows the direct relationship between gum yield and face width; and the average gum yield may be read directly from the curve for any face width from 3 to 9 inches. Figures 1-B and 1-C, however, show the corrections for tree size and width of secondary bark-bars to be applied to the basic readings from figure 1-A. Arranged in this manner, the charts are useful for predicting yields. For example, a 5½-inch face on a tree 10½ inches in diameter at 10 feet above the ground and with secondary bark-bars of 4 inches each would show an estimated yield of:

Face width 5½ inches = 60 oz. (fig. 1-A)
Diameter of tree 10½ inches = +10 oz. (fig. 1-B)
Secondary bark-bar 4 inches = + 1 oz. (fig. 1-C)
Total 71 oz.

From figure 2 the yields for the second year of work may be determined in a similar manner.

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[1] The reason that the solid line is lower than the dotted lines of slash or longleaf in figure 2 is that during the second year the French faces included in the total yielded considerably less than the American faces.

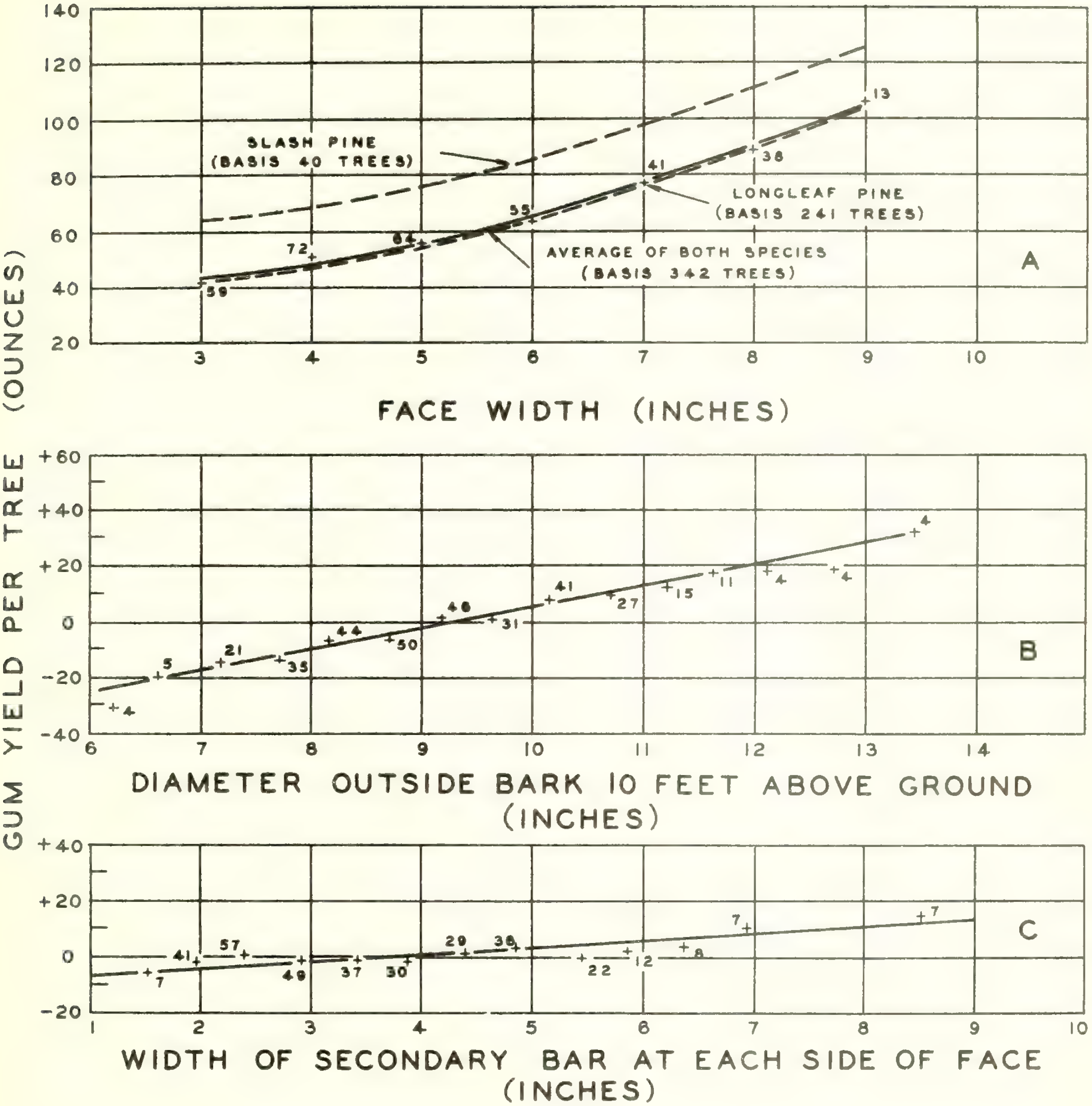

FIGURE 1: THE RELATION OF FIRST-YEAR GUM YIELD FROM FACES CHIPPED ON BARK BARS TO (A) WIDTH OF FACE, (B) DIAMETER OF TREE, AND (C) WIDTH OF SECONDARY BARK BARS. IN (A) THE YIELD MAY BE READ DIRECTLY, BUT (B) AND (C) SHOW CORRECTIONS TO BE APPLIED TO THE YIELDS INDICATED IN (A) WHEN ALLOWANCE IS MADE FOR DIAMETER OF TREE AND OF WIDTH OF SECONDARY BAR RESPECTIVELY.

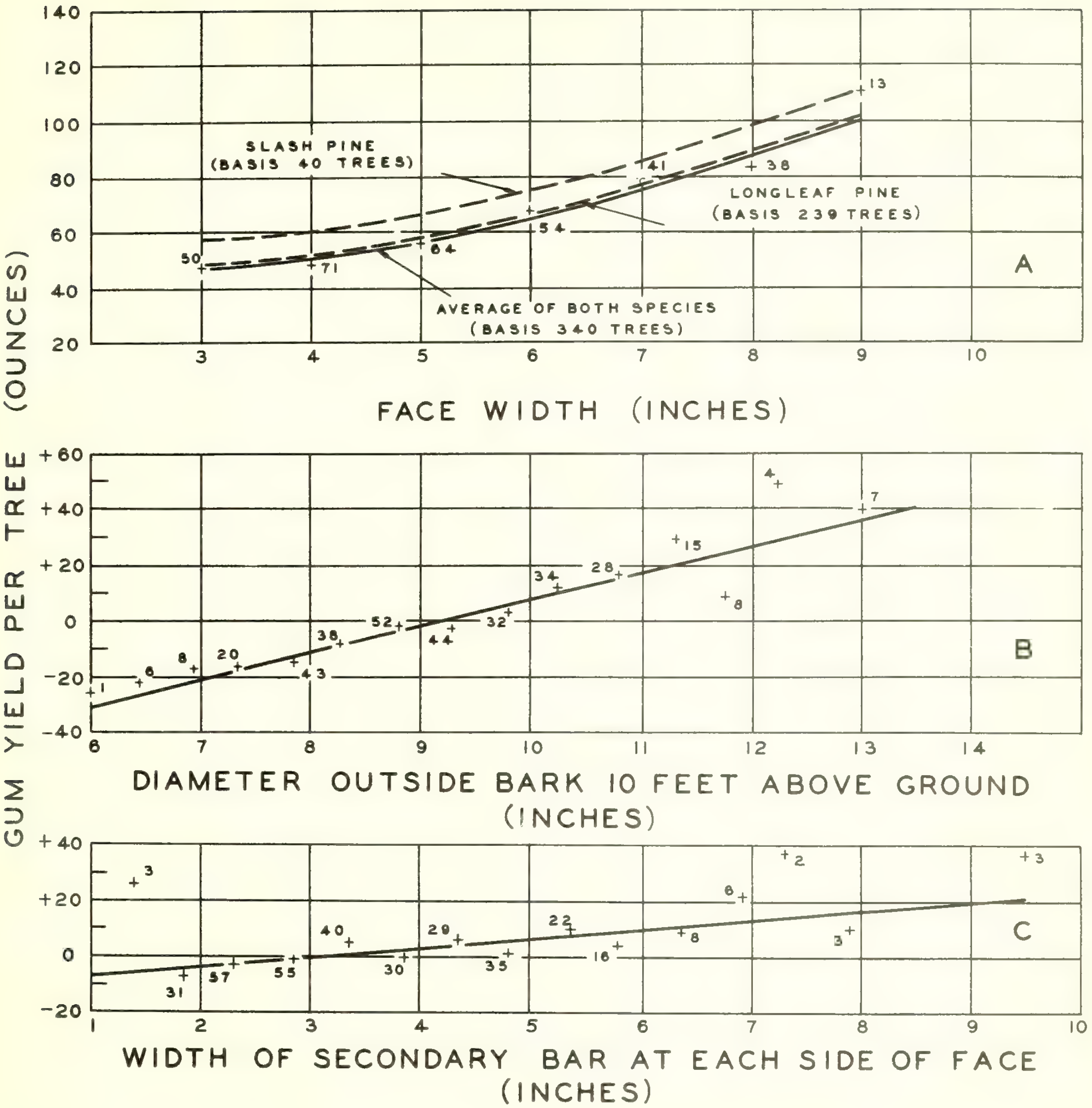

FIGURE 2 : THE RELATION OF SECOND-YEAR GUM YIELD FROM FACES CHIPPED ON BARK BARS TO (A) WIDTH OF FACE, (B) DIAMETER OF TREE, AND (C) WIDTH OF SECONDARY BARK BARS. IN (A) THE YIELD MAY BE READ DIRECTLY, BUT (B) AND (C) SHOW CORRECTIONS TO BE APPLIED TO THE YIELDS INDICATED IN (A) WHEN ALLOWANCE IS MADE FOR DIAMETER OF TREE AND OF WIDTH OF SECONDARY BAR RESPECTIVELY.

It will be noted that gum yield increased rather rapidly with increase in face width. On the average, a 6-inch face yielded about 50 percent more, and a 9-inch face about 140 percent more, than a 3-inch face during the first year, and approximately 40 and 110 percent more, respectively, during the second year. As the diameter at 10 feet above the ground increased within the limits of 7 to 14 inches, gum yield likewise showed a marked increase. As secondary bark-bars increased in size from 1.5 inches to approximately 8.5 inches, the yield increased gradually. The maximum yield for a face of given size was obtained with the maximum bark-bar width available, which permitted a secondary bark-bar of approximately 8 inches at each side of the face. The spread in yield associated with the single factor, secondary bark-bar, proved to be approximately 20 ounces for the range of 1½ to 8 inches. Four-inch secondary bark-bars produced about 6 ounces more gum per face than 2-inch secondary bark-bars, all other conditions being equal. There was approximately a 3-ounce increase in gum yield for each inch increase in width of secondary bark-bar; this increase would amount to about 1 unit of turpentine and rosin for a crop of 10,000 faces.

Although it was possible, by exercising extreme care, to maintain the secondary bark-bars at the widths specified in the experiment, it would not be expected that secondary bark-bars as narrow as 1 inch could be maintained in commercial practice, because the danger of cutting through the life-bar is too great. It does not seem advisable under any circumstances to attempt secondary bark-bars less than 2 inches wide at either side of the face. Neither does it seem advisable to leave secondary bark-bars wider than is necessary to insure a continuous vertical strip of live wood, for to do so is at the expense of either more or wider faces. For general practice, observations have indicated that 4-inch bars at the sides of the face are preferable.

While the solid-line curves in figures 1 and 2 represent slash and longleaf pines combined, the first-year gum yields of slash pine averaged about 35 percent higher than those of longleaf pine (using longleaf yields as a basis for the comparison). During the second season, however, the difference in favor of slash pine was only about 15 percent. The broken-line curves in figures 1-A and 2-A show graphically the difference between the two species. They show also that the average yield from longleaf pine increased slightly during the second season, whereas that of slash pine decreased considerably.

An incidental, though important, fact brought out by the analysis of the second-year yields is that the narrow faces--that is, those 3 to 6 inches in width--produced higher yields during the second year of working than during the first, whereas faces wider than 6 inches produced lower yields.

Gum yields in ounces per tree were read from figures 1 and 2 for slash and longleaf pines separately. These yields were then converted to barrels of turpentine per crop (10,000 faces) and the results are given in tables 1 and 2. Since the figures are based on data collected entirely during the first 2 years, they are strictly applicable only to 2 years of operation. It is believed, however, that for all but the poorest trees the indicated yields should apply for the usual turpentining period, making about the same

Table 1. - Average first-year yields of turpentine[1] per crop (10,000 faces) from faces of different widths chipped on bark-bars--classified by species, diameter of tree, and width of secondary bark-bars

Width of face	Longleaf pine				Slash pine			
	Tree diameter at 10 feet above ground (inches)							
	8	10	12	14	8	10	12	14
Inches	Barrels of turpentine per crop (first year, 32 streaks)							
	Secondary bark-bars 1 inch wide at each side of face							
3	8	13	18	22	15	20	25	29
5	12	17	22	26	19	24	28	33
7	19	24	29	33	26	31	36	40
9	28	33	37	42	35	40	44	49
	Secondary bark-bars 2 inches wide at each side of face							
3	9	14	19	23	16	21	26	30
5	13	18	22	27	20	25	29	34
7	20	25	29	34	27	32	36	41
9	28	33	38	43	36	41	45	50
	Secondary bark-bars 4 inches wide at each side of face							
3	11	16	20	25	18	23	27	32
5	14	19	24	29	21	26	31	36
7	22	26	31	36	28	33	38	43
9	30	35	40	44	37	42	47	51
	Secondary bark-bars 6 inches wide at each side of face							
3	12	17	22	26	19	24	29	33
5	16	21	26	30	23	28	32	37
7	23	28	32	37	30	35	39	44
9	32	36	41	46	39	44	48	53
	Secondary bark-bars 8 inches wide at each side of face							
3	14	19	23	28	21	26	30	35
5	18	22	27	32	24	29	34	39
7	25	30	34	39	32	36	41	46
9	33	38	43	47	40	45	50	54

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[1] Converting factors used to change weight of gum to barrels of turpentine are as follows: turpentine is 20 percent of total weight of clean gum (8 percent of the gum weight is water and trash); 7.245 pounds of turpentine equal 1 gallon; 50 gallons equal 1 barrel.

Table 2. - Average second-year yields of turpentine[1] per crop (10,000 faces) from faces of different widths chipped on bark-bars--classified by species, diameter of tree, and width of secondary bark-bars

Width of face	Longleaf pine				Slash pine			
	Tree diameter at 10 feet above ground (inches)							
	8	10	12	14	8	10	12	14
Inches	Barrels of turpentine per crop (second year, 32 streaks)							
	Secondary bark-bars 1 inch wide at each side of face							
3	10	16	22	28	13	19	25	31
5	13	19	25	31	16	22	28	34
7	19	25	31	37	22	28	34	40
9	27	33	39	45	30	36	42	48
	Secondary bark-bars 2 inches wide at each side of face							
3	11	17	23	29	14	20	26	32
5	14	20	26	32	17	23	29	35
7	20	26	32	38	23	29	35	41
9	28	34	40	46	31	37	43	49
	Secondary bark-bars 4 inches wide at each side of face							
3	13	19	25	31	16	22	28	34
5	16	22	28	34	19	25	31	37
7	22	28	34	40	25	31	37	43
9	30	36	42	48	33	39	45	51
	Secondary bark-bars 6 inches wide at each side of face							
3	15	21	27	33	18	24	30	36
5	18	24	30	36	21	27	33	39
7	24	30	36	42	27	33	39	45
9	32	38	44	50	35	41	47	53
	Secondary bark-bars 8 inches wide at each side of face							
3	17	23	29	35	20	26	32	38
5	20	26	32	38	23	29	35	41
7	26	32	38	44	29	35	41	47
9	34	40	46	52	37	43	49	55

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[1] Converting factors same as in footnote 1, table 1.

allowances for decreasing yield, as turpentining continues, which would be made for ordinary front- or back-facing.

Suppose 36 barrels of turpentine per crop were the minimum which could be accepted as profitable production, and that a 4-inch secondary bark-bar was required. Table 1 shows that, for longleaf, a tree 14 inches in diameter at 10 feet above the ground, with an unturpentined bar of 15 inches to support a 7-inch face, would be needed; for slash, a similar-sized tree having a 13-inch bar for a 5-inch face. For trees of smaller diameter--for example, 10 inches--the requirement would be an unturpentined bar capable of supporting a 9-inch face on longleaf pine or an 8-inch face on slash pine.

The results obtained in this study would seem to indicate rather clearly that for the average operator there is little chance at present of furthe utilizing profitably the narrow bark-bars (under, e.g., 12 inches) of so-called worked-out trees for turpentining. Even though there may be a slight saving in favor of chipping narrow bark-bars, by using cupping material already on location, for which there are no transportation costs, it cannot be overlooked that under the customary system of naval-stores operation all labor costs constitute only about one-fourth to one-third of the cost of production, and that cup distribution represents only about 2 percent of this. Essentially there seems to be little difference between the gum yield of a bark-bar face and that of an ordinary face, although the possibility of making wider secondary bark-bars on the ordinary face may permit a slight increase in gum yields. It is largely a matter of width of face. As shown in figures 1-A and 2-A, the gum yield increases rapidly as the face width increases from 5 to 9 inches, the widest face used in the experiment.

Summary

An experiment was conducted during 1935 and 1936 on the Osceola National Forest near Olustee, Fla., to determine the gum yields from various widths of faces on bark-bars of different widths. Face widths ranged from 3 to 9 inches and bark-bar widths from 7 to 28 inches.

Analysis showed that the most important factors influencing gum yield were, in increasing order of their importance: (1) width of face, (2) diameter of tree, and (3) width of secondary bark-bars--the live-wood bars at the sides of the new faces. Charts and tables are presented which show the effect of these factors upon gum yield.

Yields from slash pine averaged about 35 percent higher than those from longleaf pine during the first year and approximately 15 percent higher during the second year.

The gum yield from a face on a bark-bar is somewhat less than that from a normal face of similar width because of the wider secondary bark-bars possible on the latter.

OCCASIONAL PAPER No. 62

June 7, 1937

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE PLACE OF FORESTS IN A LAND-USE PROGRAM FOR THE SOUTH

By

Robert K. Winters, Forester

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

THE PLACE OF FORESTS IN A LAND-USE PROGRAM FOR THE SOUTH[1]

By Robert K. Winters, Forester,
Southern Forest Experiment Station.

In a recent Associated Press dispatch[2], I. W. Duggan, Assistant Southern Director of the Agricultural Adjustment Administration, is reported to have said that land in the cotton-growing area of the United States was only 74 percent as productive as the Nation's average soil, and that, although 34 percent of the Nation's farm population lived in the area, they received only 21 percent of the national farm income. In this statement, attention is fixed on the three primary elements in our knotty rural socio-economic problem: people, income, and land. Mr. Duggan implies that too many people in the South are producing too small an income because they are trying to raise on a large aggregate area of poor land a crop for which no adequate market exists. I know that some competent agricultural economists feel that, under efficient practices, half the farm people in the South, working half the present area of tilled land, could meet all our domestic and export needs for the products of southern agriculture and thereby double their present individual family income. Be that as it may, we now have all the people, and they are on all the tilled land. Our problem, therefore, is to give them the maximum purchasing power and the best possible living conditions while fundamental changes are being made. To do this we can, it seems to me, strive toward two specific objectives: (a) to make the land produce continuously the maximum net cash income consistent with the long-time public interest, and (b) through such production to supply the maximum opportunity for employment.

The agricultural possibilities of land use under present practices are well known, both with respect to cash income for the owner and with respect to opportunities for employment of labor. Less well known are the possibilities for employment and continuous cash income from southern lands when devoted to the cultivation of timber. It is with these latter possibilities that I wish to deal in the following pages. Although forest land offers opportunities for income from hunting, trapping, recreation, and other rights, I shall confine myself to income from immediate products of forest trees.

My data are, in part, those gathered by the Southern Forest Survey of the United States Forest Service, an activity of the Southern Forest Experiment Station with headquarters in New Orleans, La. To obtain a true picture of the supply of timber and other forest products in 1934, our survey crews took to the woods and on foot gridironed the entire South on compass lines 10 miles apart run from the Atlantic Ocean to the plains of Texas (see fig. 1). At 660-foot intervals along these lines, field crews established sample plots and classified the land as forested, cultivated, recently cleared for cultivation, recently abandoned from cultivation, marsh town, right-of-way, etc. On each forest plot, trees were counted, classified as to kind, and measured with respect to height and stem diameter; also, growth rates were determined by means of an increment borer, and all other data needed to determine stand volume and timber growth were gathered.

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[1] Address delivered at the meeting of the Association of Southern Agricultural Workers, Nashville, Tenn., Feb. 3, 1937.

[2] The Times-Picayune, New Orleans, La., page 11, Jan. 22, 1937.

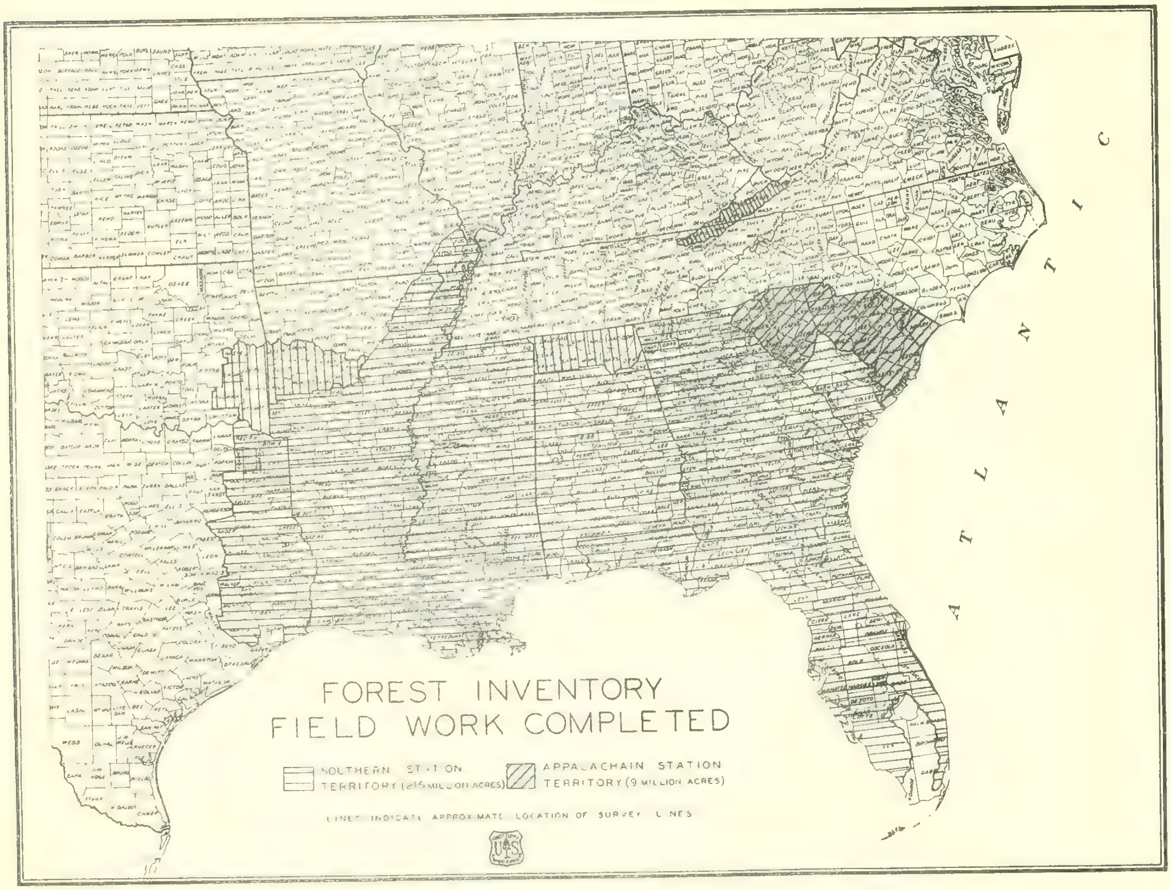
FOREST INVENTORY
FIELD WORK COMPLETED
SOUTHERN STATION TERRITORY (215 MILLION ACRES)
APPALACHAIN STATION TERRITORY (9 MILLION ACRES)
LINES INDICATE APPROXIMATE LOCATION OF SURVEY LINES
ATLANTIC

Figure 1. - Forest Survey lines covered the South from the Atlantic Ocean to the Great Plains

Figure 2 presents graphically the results of an analysis of Survey land-use data. On this chart the South has arbitrarily been divided into a number of units, whose boundaries are shown. In each of these units is a circle whose diameter is proportional to the total land area of the unit in which it occurs. The black portion of each circle represents the forest area in the given unit; the grey portion represents the area in agriculture; and the white represents the land area in other uses.

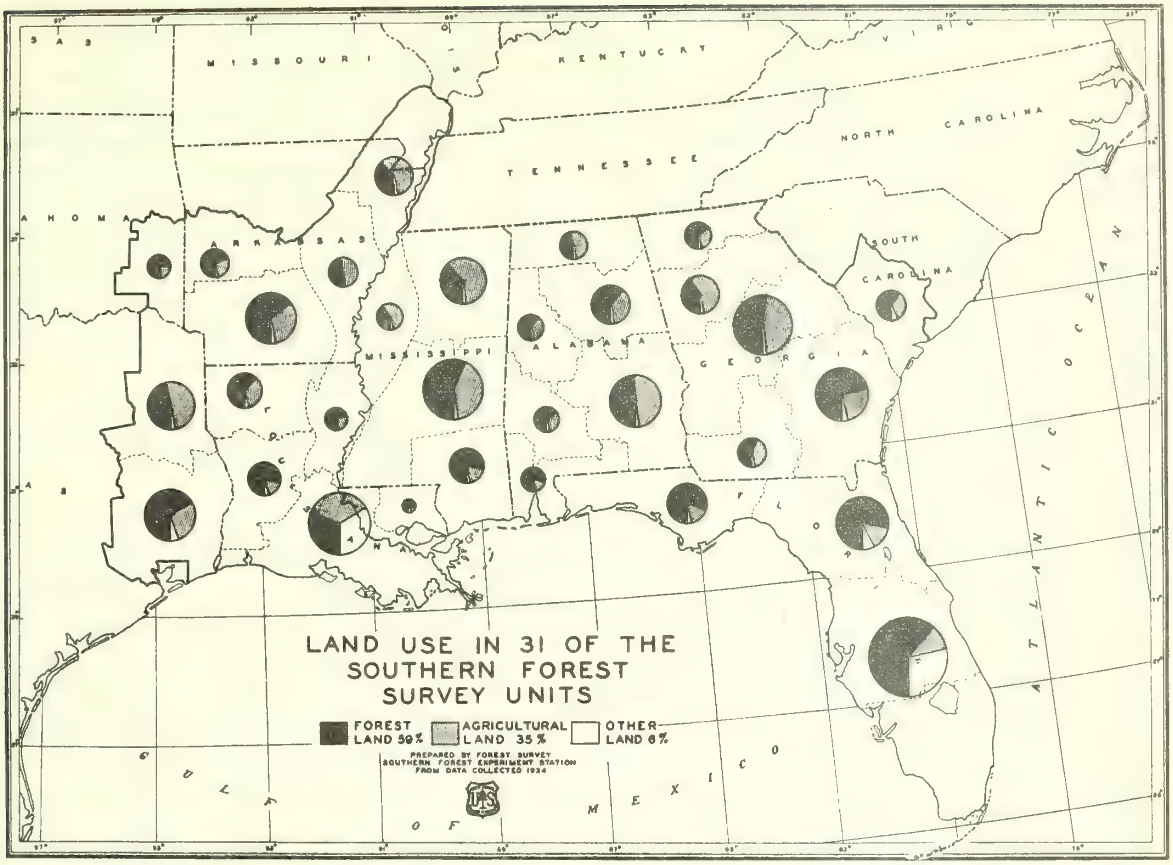

Figure 2. - Land use in the South

The predominance of forest land, shown in black on the map, is impressive, particularly along the Atlantic and Gulf Coasts. Of the 31 units shown, only 9 have less than 50 percent of their land area in forest growth and 4 of these lie in the highly agricultural Mississippi Delta region. The large areas of marsh in south Louisiana and south Florida are chiefly responsible for the increased size of the white portions in the circles representing these units.

Considering the South as a whole, the area of forest land is nearly one and two-thirds times the area of agricultural land. Furthermore, analysis of our data shows that land is being abandoned for cultivation nearly three times as fast as new land is being cleared for agriculture. Thus, as long as present trends continue, the area of forest land can be expected to increase in the South.

What can this forest land contribute in the way of cash income to land-owners and employment to labor? An answer to the first part of this question is given in table 1, where income data on four distinct kinds of forest ownership are presented. These forest incomes are based on a timber cut that does not exceed the growth, and represent, I believe, the average that is being obtained in similar sawtimber-size stands on millions of acres throughout the South without fire protection, cultural operations, or the application of other forest-management practices. These incomes represent, in effect, what the woods can do for themselves without the aid of man and sometimes in spite of him. Needless to say, these incomes can be greatly increased by building up the growing stock through a reduction in the mortality loss and through an acceleration in the growth as a result of improved selection of trees to be cut, and by improving the timber-marketing practices.

Table 1. -- Appraisal value, net annual earnings, and income as a percentage of investment for second-growth timberland

Type of ownership and of timber	Land value (i.e., without timber)	Value, land and timber	Gross annual returns per acre	Operating cost	Net annual returns per acre	Net annual income
	Dollars	Dollars	Dollars	Dollars	Dollars	Percent
Small farm - loblolly pine	3.00	8.00	1/0.90	2/0.16	0.74	9.2
Small farm - bottomland hardwood	3.00	10.00	3/0.49	4/0.16	0.33	3.3
Large commercial - shortleaf-loblolly	3.00	16.00	5/1.19	6/0.30	0.89	5.6
Large commercial - naval-stores	3.00	11.00	7/1.29	8/0.35	0.94	8.5

1/ Based on a continuous annual growth of 257 bd.ft. (International $\frac{1}{4}$-inch rule) at $2.82 per M bd.ft. and 0.36 cord (4 x 4 x 8 feet) at 50¢ per cord.

2/ Based on 15¢ per acre for taxes and 1¢ per acre for fire suppression.

3/ Based on a continuous annual growth of 175 bd.ft. at $2.10 per M bd.ft. and 0.5 cord at 25¢ per cord.

4/ Based on 15¢ per acre for taxes and 1¢ for fire suppression.

5/ Based on a continuous annual growth of 174 bd.ft. at $5.85 per M bd.ft. and 0.34 cord at 50¢ per cord.

6/ Based on 15¢ per acre for taxes, 5¢ per acre for fire protection, and 10¢ per acre for administration costs.

7/ Based on an integrated continuous use of timber for naval stores, lumber, poles, piles, and pulpwood.

8/ Based on 20¢ per acre for taxes and 15¢ for fire protection and administration.

The small-farm ownerships represent the average of some 660,000 acres of second-growth sawtimber in the loblolly pine type in eastern Texas. The small-farm owner usually has 40 or more acres of woodland adjacent to his farm land. Oftentimes he does not recognize the value of his timber, and in times of financial difficulty markets his forest products to poor advantage. As a result, he realizes less per thousand board feet of timber sold than his timber is actually worth. In this example, the values of standing timber and annual timber growth are based on a price of only $2.82 per thousand board feet of lumber; in many parts of the South, timber of comparable size and quality is being bought for this price. This farmer's administrative expense can be considered as nil and his fire-protection cost practically so. On this basis, and by cutting only the growth, he realizes 74¢ per acre net or more than 9 percent on the land and timber value. Figure 3 shows a stand of second-growth pine in eastern Texas similar to the average upon which this income calculation was based.

The incomes and values for the small-farm owner in the southern bottomland hardwood type, where growth is somewhat less than in the pine type of eastern Texas, are representative of second-growth sawtimber-size river-bottom hardwood stands anywhere in the South except in the Mississippi River Delta, where land values and taxes are generally higher than shown here. This kind of owner also frequently underrates the value of his timber and during times of stress or in emergency sells it for less than its real value. Accordingly he earns 33 cents net per acre or 3.3 percent on his total investment in land and timber.

The incomes and values for the large commercial ownership in the loblolly-shortleaf pine region are based on some 300,000 acres of second-growth sawtimber-size pine in Arkansas. In this case the owner is assumed to know the actual market value of his timber and to be in a position to market it most effectively. His net annual income per acre is 89 cents or approximately 5.6 percent of the value of his land and timber.

The large commercial ownership of the naval-stores pine type in Florida shows a net annual return of 94 cents or 8.5 percent on the combined value of land and timber. This is typical of many thousands of acres of second-growth longleaf and slash-pine timber, worked for the gum from which turpentine and rosin are derived. This income is based on the full use of the trees for naval stores before selling the completely worked timber for such uses as poles, piles, lumber, and pulpwood.

May I emphasize again that these are yields from second-growth sawtimber-size stands as they now exist. At present these stands are understocked particularly in the larger size-classes; in general they are not protected from fire, nor are they being cut in such a way as to insure maximum timber growth. If they were fully stocked and were properly cut, and if the products were effectively marketed, net money yields per acre would reasonably be expected to double or treble, assuming present market conditions. On the average, as a result of improvement in management, hardwood stands can be expected to show a relatively greater increase in money yield than pine.

And now, what opportunities does forest land offer for employment? According to Survey studies of forest employment in the South, approximately three-fifths of a man-day of labor can be provided each year through the cutting and manufacturing of the growth on an average acre of second-growth forest land such as we have been discussing. This employment includes work in the woods, cutting timber for any kind of industrial use; it also includes the labor involved in all transportation of commercial logs, bolts, billets, and cordwood, except that on common-carrier railroads and barge lines. Furthermore, it includes the employment provided by mill- and office-work in such primary forest industrial plants as sawmills, pulp and paper mills, veneer and stave plants, creosoting plants, and destructive-distillation plants.

What, in brief, does the forest mean to an area such as a State or portion of a State? In southeastern Texas, for example, are some 4,900,000 acres of pine timberland. Some of it is now growing sufficient timber to produce a net annual income of 74 cents per acre, and we can safely say that, if restocked and protected from fire, all of it could produce equally well. In this region, approximately 1,170,000 acres of hardwood land is, or can be, producing 33 cents per acre. This pine and hardwood forest area is, therefore, capable of producing approximately $4,000,000 net income per year. Three-fifths of a man-day of labor in forest industries per acre of forest land per year is equivalent to more than 3½ million man-days of labor per year. At $1.25 per man-day, this represents about 4½ million dollars. Under present economic conditions and with but slightly improved forest-management practices, somewhat over 6,000,000 acres of forest land could bring in more than 8½ million dollars annually through the sale or use of trees on the stump and through the labor involved in the harvesting and primary manufacture of products therefrom.

And now, to relate all of this to people, income, and land, the three primary elements of our problem as outlined by Mr. Duggan. Apparently he has been thinking in terms of salvation for the rural South through a crop-controlled and otherwise rejuvenated agriculture. Unquestionably, agriculture now is, and probably always will be, the mainstay of the rural population of the South. Nevertheless, Southern farmers, by caring for their forests, by properly harvesting their own woodland products, and by part-time employment on commercial forest land, can materially increase their yearly cash income. Approximately 59 percent of the land area in the South supports a forest growth nearly all of which is capable of producing a net annual income of as much as 75 cents or $1.00 per acre, and about 35 percent of this forest area is in farm woodland. That the Southern farmer is already very much in the timber business is further indicated by the fact that more than 40 percent of the total farm area in the South is growing a timber crop.

The people of the rural South have in their extensive forests a resource that grows and that furnishes income both through the sale of products and through the labor involved in their marketing and manufacture. Properly handled, these forests can and will play their full share in the solution of our perplexing rural problem involving people, income, and land.

OCCASIONAL PAPER No. 63 June 11, 1937

SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE OPPORTUNITY FOR FORESTRY IN LOUISIANA'S AGRICULTURAL PROGRAM

By

E. L. Demmon

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

THE OPPORTUNITY FOR FORESTRY IN LOUISIANA'S AGRICULTURAL PROGRAM [1]

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The Louisiana farmer's opportunities for profit through management of his woodlands are not always fully appreciated. As a matter of fact, farm woodlands hold a high position in Louisiana's agricultural economy. According to the most recent census figures (1934), this State contains approximately 3,427,000 acres of farm woodlands, or an average of 20 acres per farm. These woodlands constitute about 33 percent of the State's farm land and 21 percent of its total forest area of approximately 16.2 million acres. The total area in cultivation in 1934 was 4,756,500 acres. In 1935, the last year for which data are available, the cash income from farm-forest products in Louisiana totaled $1,688,000. Compared with forest lands elsewhere in the United States, Louisiana farm woodlands have an outstanding advantage in that the potential rate of tree growth in this general section exceeds that in any other forest region of the country.

Of the total land area of Louisiana, 56 percent is in some type of forest. This can be roughly divided among the principal forest types as shown in table 1.

Table 1. Acres of productive forest land in Louisiana in the various forest types and forest-conditions

Forest type	Forest condition				Percent
	Old growth	Second growth	Clear-cut	Total	
	------------ Thousand acres ------------				
Longleaf-slash	212	1,153	1,275	2,640	16
Shortleaf-loblolly-hardwoods	237	4,704	51	4,992	31
Upland hardwoods	184	746	5	935	6
Bottomland hardwoods (including cypress)	2,709	4,691	121	7,521	47
Total productive [2]	3,342	11,294	1,452	16,088	100
Percent	21	70	9	100	

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[1] Address before the Farm Chemurgic conference at Shreveport, La., April 15, 1937.

[2] Non-productive forest area is estimated at 123,000 acres, giving a total forest area in the State of 16,211,000 acres.

According to the preliminary estimates of the South's forest resources, as obtained by the Forest Survey, Louisiana contained (in 1934) approximately 29½ billion board feet (Doyle rule) of sound, merchantable sawtimber (pines at least 9 inches in diameter at breast height, and hardwoods at least 13 inches in diameter). This was made up as shown in table 2.

Table 2. Volume of sawtimber in Louisiana in the various species-groups.

Tree species-group	Volume (Doyle rule)	Percent of total
	million board feet	
Longleaf and slash pines	3,543.7	12
Shortleaf and loblolly pines	5,796.4	20
Hardwoods[1]	20,077.4	68
Total all species	29,417.5[2]	100

1/ Hardwoods include principally red gum, red and white oaks, black gum, tupelo, bitter pecan, cypress, and ash.

2/ Equivalent volume using Scribner rule is 37,641.9 million board feet, and by International ¼ inch rule (approximating mill tally), 42,441.3 million board feet.

In addition to the merchatable sawtimber given above, Louisiana forests include in sound trees under sawlog size the amounts of cordwood (standard cords, including bark) shown in table 3.

Table 3. Volume of cordwood in Louisiana in the various species-groups.

Tree species-group	Volume	Percent of total
	thousand cords	
Longleaf and slash pines	767	1
Shortleaf and loblolly pines	11,997	19
Pulping hardwoods[1]	20,793	34
Nonpulping hardwoods[2]	26,185	42
Cypress	2,384	4
Total all species	62,126	100

1/ Principally red gum and tupelo.

2/ Principally red and white oaks, bitter pecan, and ash.

The cutting and marketing of forest products, both from the farm woodland and from industrially owned forest land, have represented a considerable source of income and opportunity for employment, either full-time or part-time, to many Louisianians. The Federal Census figures (1929) showed that the forest-products industries employed approximately 38,000 persons, or 38 percent of the total people employed in all manufacturing industries in the State, paid out salaries and wages of more than 35 million dollars, and produced materials worth more than 115 million dollars annually. The cutting of cordwood, pulpwood, sawlogs, poles, and ties, and the production of naval stores (turpentine and rosin), are particularly suited to part-time employment of farm labor and equipment. Furthermore, Louisiana forests offer opportunities for expansion of the present industries and development of new wood-using industries, which, if taken, will absorb many people now on submarginal farms and provide part-time work for many farmers on subsistence homesteads.

Table 4 shows the number of wood-using plants in Louisiana in operation and the number of full-time laborers required in 1934.

Table 4. Wood-using plants in Louisiana and men employed, 1934.

Type of wood-using plant or commodity		Number of establishments	Number of full-time laborers 1/		
			Woods	Mill or plant	Total
	daily capacity				
Pine sawmills	80 M ft. and over	20	3,804	7,120	10,924
	40 M ft. to 79 M ft.	8			
	20 M ft. to 39 M ft.	36			
	19 M ft. and under	169			
Hardwood sawmills	80 M ft. and over	4			
	40 M ft. to 79 M ft.	27			
	20 M ft. to 39 M ft.	21			
	19 M ft. and under	84			
Cypress sawmills	80 M ft. and over	0			
	40 M ft. to 79 M ft.	4			
	20 M ft. to 39 M ft.	4			
	19 M ft. and under	10			
Veneer		14	285	141	426
Cooperage stock		24	261	377	638
Pulpmills		6	6,468	8,697	15,165
Treating plants		10		681	681
Distillation plants (steam solvent)		4	442	294	736
Turpentine stills		3	231	17	248
Posts, poles, piling, and crossties		-	1,537		1,537
Miscellaneous		15	1,535	2,095	3,630
Fuelwood (industrial) 2/		-	345	-	345
Total		463	14,908	19,422	34,330

1/ Based on 240 working days per year, 10 hours per day.

2/ In addition to this item, the labor used in cutting fuelwood and other forest products used locally is equivalent to full-time employment for approximately 12,438 men.

During the same year (1934), it is estimated that the forest industries in Louisiana cut approximately 1.8 billion board feet of sawtimber, which represented 2.3 percent of the total sawlog-size trees at that time. The additional drain in cordwood, for uses other than lumber production, and including that used on farms, has not yet been determined.

In the past, Louisiana farmers usually have not taken advantage of the opportunity to increase the income from their woodlands through improved management. The utilization of these woodlands is far from ideal, and much remains to be done before farm woodlands are adequately protected against fire, overgrazing, insects, diseases, and abnormal erosion. As elsewhere in the South the coming of the small mill has been the chief cause of overcutting. In many cases farmers have sacrificed stumpage under pressure of financial difficulties or simply because a small sawmill happened to be located temporarily in the vicinity. Often farmers owning small mills have converted all their merchantable timber into lumber, ties, posts, or other products for the sake of immediate cash income, when through selective cutting and careful milling they could have obtained an equal income without the sacrifice of adequate growing stock.

The result of overexploitation of farm woodlands is very evident in the considerable acreage of cut-over, burned-over woodland in Louisiana that has been forfeited to the State for nonpayment of taxes. In the entire State as of November 1934, there were 3,441,860 acres in tax default, or 11.9 percent of the gross area of the State; of this, approximately 1,720,000 acres were in forest. While this was the situation in 1934, there has been a marked improvement since that time. Data are not available as to the exact area now in State title for nonpayment of taxes, but it is estimated that a considerable percentage of the area in tax default in 1934 has now been restored to the tax rolls. This reduction in forfeited acreage has been brought about by the increased prices of farm products, by Federal benefit payments, and by legislation favoring easier redemption of forfeited and delinquent property.

Of the total number of tracts adjudicated to the State prior to 1933, 77 percent were less than 100 acres each. About half the area in these tracts was forest land, and most of it was owned by farmers. Through overcutting and lack of management, followed by depletion resulting from uncontrolled fires, this land has often been reduced to a waste, on which the owner could no longer afford to pay taxes. Its forfeiture consequently has increased the taxes on land remaining in private ownership, tending both to force it also into forfeiture and to curtail public services without any reduction in taxes. Although forest growth in Louisiana is potentially rapid, it cannot compete with uncontrolled fires, destructive cutting, and confiscatory taxes.

The individual farmer or other owner of small woodlands is often exploited through receiving an inadequate price for his stumpage and also by the overcutting of his timber. Therefore, in arranging for the sale of the products of his timberland, he should not neglect to "shop around" among sawmill operators and other users of forest products, and thus obtain the best price possible for his stumpage or logs. In doing this he can avail himself of the help of agencies, such as the State and extension foresters and the parish agricultural agents. He can also help to protect himself in the marketing of his timber products through the establishment of marketing associations and through the building up of local utilization plants.

Louisiana farm woodlands contain much raw material potentially available for the production of pulpwood, in addition to other forest products. This is particularly opportune at the present time because of the recently expanding pulp and paper industry. Louisiana has a particular interest in pulp mills, with six already established in the State (Bogalusa, Bastrop (2), Monroe, Hodge, and Elizabeth) and others in prospect. At present, the South dominates the field in the production of pulpwood where the sulphate process is used, the principal products being brown kraft wrapping paper, bags, and boxboards. Laboratory research indicates that excellent newsprint can be made from southern pines.

Among the factors which should be considered in the location of pulp mills are: availability of ample and continuous supplies of high-quality pulping cordwood, labor, power and fuel, water, and chemicals; transportation facilities; proximity to markets; and taxes.

Although the prospects of further expansion in the pulp and paper industry in Louisiana are favorable, certain precautions must be observed if this expansion is to be on a sound basis; and the following policy should govern this expansion:

1. There should be no more pulp mills in Louisiana than its forest lands can support from timber not needed for established forest-using industries.

2. Insofar as economic circumstances will permit, new pulp mills should be fairly well distributed throughout the State and not concentrated in restricted localities.

3. Each new and existing plant should plan for permanency and should utilize timber in its territory on a sustained-yield basis, with full regard for the needs of other wood-using industries, integrating the production of pulpwood with other forest products of greater value.

Aside from cash income through sale of forest products, the production of fuelwood, posts, poles, lumber, and similar products for use on the farm represents an important part of the total farm income. In Union Parish, La., investigations by the Southern Forest Experiment Station, in conjunction with the Louisiana Agricultural Experiment Station, showed that in 1930 the value of forest products cut and used on 119 farms averaged $33 per farm, or 48 cents per acre of woodland. The cut of products thus used was concentrated on a small percentage of the total woodland area, so that for the land actually cut-over the value was much greater.

Other studies by the Southern Station show that the average Louisiana farm uses about 11.4 cords of fuelwood per year (1934), while the average number of fence posts used annually per farm is estimated at about 60. Poles that go into cribs, barns, and other farm structures average 0.44 cords per farm. Most of these materials are cut from the farmer's own woodland. If the farmers had to pay for these products from their pocketbooks instead of obtaining them from their woodlands, the cost would be considerable.

As a concrete example of the tree growth that is taking place on Louisiana farms, figures obtained by the Southern Forest Experiment Station in a study of the financial aspects of growing timber, in Union Parish, show that in 1929, more than 40 percent of the land in this parish was in farm woodland. Although studies of individual farms showed that very few farmers were practising good forestry, it was found that in a farm woodland representing the parish average the well-stocked pine stands were growing at an annual rate of more than 500 board feet per acre and that the average annual growth for all the farm woodlands in the parish was more than 200 board feet per acre. The possible annual income from sale of stumpage and pulpwood, at the prices then prevailing, averaged $2.47 per acre for well-stocked stands and 71 cents per acre for the whole woodland. The cost of taxes, fire protection, and forest management per acre per year was 31 cents for the well-stocked areas and 25 cents for the whole woodland. Thus, the indicated net profit per acre per year was $2.16 for the well-stocked woodland and 48 cents for the whole woodland. These figures present a strong argument for careful protection and management, since on well-stocked woodlands the net profit per acre was more than four times as great as that on average woodlands.

It behooves the owner of a farm woodland, whether he be a farmer or an urban resident, to protect his property carefully, manage it wisely, and cut it conservatively. To obtain protection against fire is in general a relatively simple matter. Federal allotments are made available for this purpose under the provisions of the Clarke-McNary Law; and the Division of Forestry of the Louisiana Department of Conservation cooperates with owners or groups of owners of forest land in protecting these properties from fire. With Federal and State cooperation, owners of Louisiana woodland can protect their forest properties from fire at an annual cost of about 2 or 3 cents per acre. Owners of small tracts in localities where it is impossible to establish protection units can at least plow firebreaks around their woods, remove snags and down timber, and observe care in the use of fire.

If reproduction is desired in the longleaf pine belt, woodlands must be protected against hogs where these animals are numerous. This can be done without excessive cost in relation to ultimate returns on the investment by building and maintaining good stock-fences. An abundance of pasture is available without overgrazing of farm woodlands.

A third form of protection that is today receiving belated attention is protection against erosion. In Louisiana, since 1933 there have been established a number of Civilian Conservation Corps camps, which, under the technical supervision of the Soil Conservation Service, are undertaking a program of controlling soil erosion. This work is a part of a comprehensive program for controlling rapid run-off of rain water and the consequent washing away of the valuable top soil. The method of stopping or healing gullies is largely to revegetate them by planting trees, vines, or grasses. To do this in the larger gullies, low temporary check-dams of brush, poles, or wire are built; the banks are reduced to an angle of repose; top soil is then put into the gully; and soil-binding trees, vines, or grasses are planted. These improvements, in addition to their direct effect in checking erosion, will serve as demonstrations to guide the farmers in their efforts to heal gullies on their farms. Areas on which abnormal erosion has been checked can be put to work growing crops of black locust or other timber. An important corollary of this gully-healing work is the correction of poor agricultural practices by the farmer himself through the use of improved methods of cultivation, including terracing and contour plowing, lack of which has been an important factor in excessive run-off from slopes.

Livestock production offers another means of using farm woodlands and contributes to the income and subsistence of many Louisiana farmers. Since present production of livestock falls far short of meeting local market needs, there is a considerable field for expansion, although one handicap to the economical production of livestock in Louisiana is the lack of improved pastures. In this connection it should be pointed out that livestock may cause damage to the woodland. Furthermore, the widespread winter-burning, which is practised in certain parts of the State to remove the accumulation of dead grasses in order that fresh feed may be more easily available to livestock in the spring, is done as a rule, without regard to the possibility of damage to the forest; and where the production of pulpwood and timber products is the dominant purpose, full stands can best be obtained by excluding livestock. It might be mentioned, in addition, that Louisiana farm woodlands are destined to become increasingly important for the production of game.

In the field of forest utilization, the farmer's job is not difficult. Instead of clear-cutting his merchantable timber, the woodland owner should practise selective cutting and thus get a continuous income. For his pulpwood and posts he can remove trees that are defective for lumber purposes and that are interfering with the development of other trees. Such culling increases the growth and value of the remaining stand. He can thin out young stands for firewood, crossties, or pulpwood, and by watching the market can arrange to make these thinnings when the cut material will bring the best prices. Even if he desires to sell or cut his timber for lumber, he should not slash off everything on the ground. He will get more for his logs if he sells by grade rather than by gross volume. Ordinarily, selective cutting costs nothing aside from the owner's time, and its returns continue for many years. Trees in the woods are like capital in the bank; their new growth corresponds to the interest. An owner of Louisiana woodland can well afford to pay taxes assessed at a reasonable rate on a fair valuation on managed forest land that is highly productive and is returning a profit on the investment. He cannot afford to pay taxes on woodland that has been denuded beyond hope of repair during his lifetime, or even on good timberland that is assessed at an inequitable rate.

In managing his woods, skilled help is readily available to the farmer. Louisiana has an extension forester working, in cooperation with the State and Federal forestry agencies and through the parish agricultural agents, to aid owners of forest lands in establishing sound forestry practices. Through joint efforts, also, extension foresters and parish agricultural agents are training 4-H club members in forestry practices and are establishing demonstration areas. The Louisiana Division of Forestry also advises farmers on their forest problems and distributes trees for planting at cost. Printed matter on many phases of forest protection, management, and utilization is available through this agency.

The United States Forest Service maintains, with headquarters at New Orleans, La., the Southern Forest Experiment Station, which conducts research on technical forestry problems to determine the best methods of growing timber in the Southern States. Investigations are under way in the fields of silviculture and forest management, fire protection, reforestation, naval-stores production, erosion control, forest economics and land-use, and other related subjects. The current findings of this Station are made available to the forestry and agricultural agencies throughout Louisiana and the other

Southern States, and these agencies disseminate the information to forest-land owners. The results of the Southern Station's research program should serve as the basis for the scientific practice of forestry and thus promote the full use of the immense area of farm woodland and other forest land in Louisiana and the other Southern States, both for timber growing and for associated purposes such as watershed protection, recreation, and game management.

All these agencies are working in the interest of the Louisiana farm-woodland owner, but the final application of the methods they recommend is something that the farmer himself must carry out. If and when he does apply these methods, he will learn that the results will be more than worth the effort.

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OCCASIONAL PAPER No. 64 June 21, 1937

THE EFFECT OF TURPENTINING ON THE GROWTH OF LONGLEAF AND SLASH PINE

By V. L. Harper, Senior Silviculturist.

Longleaf and slash pine have long been recognized as "dual-purpose" trees, a term which is meant to imply that the living trees can be chipped for gum naval-stores products for several years prior to their being felled for wood products. The full significance of this dual use is being realized now more than ever before. The development of the pulpwood industry in the South, simultaneously with the increased appreciation of the needs of the region for other wood products such as poles and sawlogs, has caused the various industries to question whether such dual use is best for their respective interests. Important among the issues considered are the probable effects of turpentining on volume and growth of the timber.

It should be pointed out that turpentining in the past has taken a heavy toll through excessive mortality, especially as the result of wind breakage. The trees were mechanically weakened by deep chipping and by the practice of making deep incisions in the turpentine face for attaching gutters. Also, many trees were further weakened by the activities of the turpentine borer, which usually gains entry through the turpentine face following fires that have removed the protective coating of gum. The following excerpt from a report [1] by the Southern Forest Survey shows the heavy drain on the total volume and growth on a survey unit of 9 1/2 million acres in northeastern Florida:

> "Although the current turpentining practices in this region are relatively conservative when compared with those in other regions, the naval-stores industry exacts an excessive toll from the forest. As a result of chipping small trees, placing too many cups on some trees, deep chipping, carelessness with fire, and other bad practices, turpentining causes an excessive reduction in rate of growth and an increase in rate of mortality of turpentine pines as well as an actual reduction in sawtimber volume, owing to the scars which result from the work. During 1934, the longleaf-slash turpentine forest in northeastern Florida, if they had not been turpentined, would have produced 210,300,000 board feet (lumber tally) more than they did. This is a part of the price which the region pays for its naval-stores industry. The significance of the loss in annual increment is shown by the fact that it slightly exceeds the combined cut from pine for lumber, ties, poles, piles, and all other wood products during that year. Since it seems inevitable that the naval-stores industry will continue to be an important user of the forests in this region, the outlook for other forest industries will be limited thereby in scope, character, and volume of production."

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[1] This report is now in manuscript and will probably be published in 1937 under the title "Forest Resources of Northeastern Florida."

While excessive loss in volume due to turpentining is to be deplored, it should be recognized that naval-stores gum is produced by the tree at the expense of wood, and consequently some reduction in growth during the turpentining period must be expected. Despite the fact that the naval-stores industry has been harassed by widely fluctuating market-prices throughout its history, the use of longleaf and slash pine for the production of naval stores has been, and probably always will be, an attractive business venture. Certainly with prevailing naval-stores lease prices of 3¢ to 8¢ per tree per annum and with the period of turpentining a single tree extending over 10 to 20 years, the timberland owner should not hesitate to turpentine his trees, especially if these same trees, when converted into pulpwood (to use only this one wood-product as an example), bring under current prices less than 10¢ each.

One of the attractive features of the region in which slash and longleaf pine occur, is that integrated forest-product use here seems both possible and practicable; and serious attention is being directed by those interested in the forest resources of the region to develop better forest-management practices. Studies by the Southern Forest Experiment Station have already indicated that excessive loss of volume and growth in turpentined second-growth forests can be averted if the stocking is regulated, if fire is controlled, if the best turpentining practices are used, and if provision is made for early utilization of the worked-out trees. Since it seems reasonable to assume that any forest property under moderately careful management would have a large measure of success in carrying out these measures, the problem then narrows down to the actual retarding effect of turpentining on the growth rate of the tree during, and subsequent to, the process.

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It will be noted in table 1 that for both species of pine the average reduction in growth rate (as measured in cubic feet) during turpentining is approximately 27 percent for 1-face trees and about 40 percent for 2-face trees, whether the faces are put on in succession or simultaneously. Stated in another way, 1-face trees grew 73 percent as fast when worked as they would have grown if they had not been worked, and 2-face trees grew 60 percent as fast. Although no data are available for 3-face trees, they would probably increase in volume during the period of turpentining at about 50 percent of the rate of unturpentined trees.

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The retardation in growth seems to be attributable to two things: (1) a diversion of the tree's photo-synthetic products to gum rather than to wood; and (2) to the checking of translocation and the flow of solutes by the face. This latter effect would, of course, vary with the width of the scar or the amount of girdling of the tree. Following the cessation of turpentining, as the face scars healed over, the growth rate could be expected to return gradually to normal for an unturpentined tree. It is doubtful, however, whether any management plan should contemplate anything other than the immediate cutting of worked-out timber, if this is at all practicable, in view of the excessive losses possible in turpentined timber.

When discussing the effect of turpentining on volume growth, it should be kept in mind that the loss in volume, except for that lost in the butt log in wood removed with the turpentine hack, is simply caused by a reduction of the growth after turpentining begins, and that while the rate of growth for that period may be reduced considerably the loss in volume over the entire life of the tree is, nevertheless, rather small, as the following example illustrates:

A 9-inch longleaf pine 50 feet tall has a cubic volume of 9.1 feet. Growing at the rate of 1 inch in diameter in 5 years it would become a 10-inch tree 55 feet tall at the end of a 1-face or 5-year period if unturpentined.[1] This represents a total volume at the end of the 5-year period of 12.5 cubic feet or a growth of 3.4 cubic feet for the period. The same tree, if turpentined, would reach a total cubic volume of 11.6 feet, but in addition would produce about 35.7 pounds of gum. The actual loss in total cubic volume of the tree is only about 7 percent. That is, the volume of a crop of 10,000 one-faced trees at the end of a 5-year period is reduced only 7 percent in exchange for which approximately 950 barrels of gum have been obtained.

It should be noted that these results do not permit one to make an unqualified recommendation to turpentine before cutting. In the first place returns from naval stores may not compensate for the loss in high-grade lumber in very large trees. Also it has been observed that old-growth trees, owing largely to their slower growth and greater proportion of heartwood, are more susceptible to damage (e.g., from blue stain and insects) and are more likely to die as a result of turpentining than are young, vigorous trees.

The results do indicate, however, that if conservative naval-stores practices are used and if the young stands are put under fire protection and good management, the loss in wood volume due to turpentining is so low as to be no serious deterrent to naval-stores operations before cutting for the final product.

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OCCASIONAL PAPER No. 64 June 21, 1937

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THE EFFECT OF TURPENTINING ON THE GROWTH OF LONGLEAF AND SLASH PINE

By V. L. Harper, Senior Silviculturist.

Longleaf and slash pine have long been recognized as "dual-purpose" trees, a term which is meant to imply that the living trees can be chipped for gum naval-stores products for several years prior to their being felled for wood products. The full significance of this dual use is being realized now more than ever before. The development of the pulpwood industry in the South, simultaneously with the increased appreciation of the needs of the region for other wood products such as poles and sawlogs, has caused the various industries to question whether such dual use is best for their respective interests. Important among the issues considered are the probable effects of turpentining on volume and growth of the timber.

It should be pointed out that turpentining in the past has taken a heavy toll through excessive mortality, especially as the result of wind breakage. The trees were mechanically weakened by deep chipping and by the practice of making deep incisions in the turpentine face for attaching gutters. Also, many trees were further weakened by the activities of the turpentine borer, which usually gains entry through the turpentine face following fires that have removed the protective coating of gum. The following excerpt from a report 1/ by the Southern Forest Survey shows the heavy drain on the total volume and growth on a survey unit of 9 1/2 million acres in northeastern Florida:

> "Although the current turpentining practices in this region are relatively conservative when compared with those in other regions, the naval-stores industry exacts an excessive toll from the forest. As a result of chipping small trees, placing too many cups on some trees, deep chipping, carelessness with fire, and other bad practices, turpentining causes an excessive reduction in rate of growth and an increase in rate of mortality of turpentine pines as well as an actual reduction in sawtimber volume, owing to the scars which result from the work. During 1934, the longleaf-slash turpentine forest in northeastern Florida, if they had not been turpentined, would have produced 210,300,000 board feet (lumber tally) more than they did. This is a part of the price which the region pays for its naval-stores industry. The significance of the loss in annual increment is shown by the fact that it slightly exceeds the combined cut from pine for lumber, ties, poles, piles, and all other wood products during that year. Since it seems inevitable that the naval-stores industry will continue to be an important user of the forests in this region, the outlook for other forest industries will be limited thereby in scope, character, and volume of production."

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While excessive loss in volume due to turpentining is to be deplored, it should be recognized that naval-stores gum is produced by the tree at the expense of wood, and consequently some reduction in growth during the turpentining period must be expected. Despite the fact that the naval-stores industry has been harassed by widely fluctuating market-prices throughout its history, the use of longleaf and slash pine for the production of naval stores has been, and probably always will be, an attractive business venture. Certainly with prevailing naval-stores lease prices of 3¢ to 8¢ per tree per annum and with the period of turpentining a single tree extending over 10 to 20 years, the timberland owner should not hesitate to turpentine his trees, especially if these same trees, when converted into pulpwood (to use only this one wood-product as an example), bring under current prices less than 10¢ each.

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OCCASIONAL PAPER No. 65 July 19, 1937

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE EFFECT OF NUTRIENT DEFICIENCY ON THE GROWTH OF LONGLEAF PINE SEEDLINGS

by

L. J. Pessin, Associate Forest Ecologist

Soil Conservation Service
Region [illegible]
Division of Information and Education

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

THE EFFECT OF NUTRIENT DEFICIENCY ON THE GROWTH OF LONGLEAF PINE SEEDLINGS

By L. J. Pessin, Associate Forest Ecologist,
Southern Forest Experiment Station,
New Orleans, La.

Longleaf pine (Pinus palustris Miller) in its natural range on the Gulf Coastal Plain often inhabits soils of low fertility. On such soils longleaf pine seedlings frequently grow poorly and show evidence of low vigor, but the specific cause for this poor growth, both under natural conditions and in the nursery, is often difficult to ascertain. A preliminary study was made, therefore, to determine whether it is possible to recognize seedling conditions or symptoms caused by the deficiency of specific mineral elements in the soil. If such symptoms can be recognized, nursery soils can then be specially treated to correct specific nutrient deficiencies.

Longleaf pine seedlings of low vigor often become infected with the brown-spot needle blight (Septoria acicola (Thüm.) Sacc.), which frequently causes almost complete defoliation. Siggers [1] points out that the needle-blight disease is an important factor in the frequent retardation of growth of longleaf pine seedlings. Since susceptibility to this disease depends to a large extent on the vigor of the seedlings, a second object of this preliminary study was to determine the influence of various mineral nutrients on the vigor and general development of longleaf pine seedlings.

Method of Study

Fresh longleaf pine seeds of uniform weight (75 mg.) were germinated between moist paper towels. When the seedlings were three weeks old (i.e., in the cotyledon stage) they were placed in the top of 2-quart mason jars, over the mouths of which were placed pieces of paraffined kraft paper. The roots of the seedlings, which were inserted through holes in this paper, extended into the solution below. The cultures included (1) a four-salt full nutrient solution [2] containing the essential elements nitrogen (N) as calcium nitrate ($Ca(NO_3)_2$) and potassium nitrate (KNO_3), potassium (K) as potassium nitrate (KNO_3) and potassium dihydrogen phosphate (KH_2PO_4), phosphorus (P) as KH_2PO_4, sulphur (S) as magnesium sulphate ($MgSO_4$), magnesium (Mg) as $MgSO_4$, calcium (Ca) as $Ca(NO_3)_2$, and iron (Fe) as ferric chloride ($FeCl_3$);

---

[1] Siggers, Paul V. The brown-spot needle blight of longleaf pine seedlings. Jour. Forestry 30: 579-593. 1932.

[2] The full nutrient solution contained:

Calcium	132 p.p.m.
Nitrogen	421 " " "
Potassium	141 " " "
Phosphorus	140 " " "
Magnesium	43 " " "
Sulphur	159 " " "
Iron	Trace

(2) a similar solution but lacking nitrogen; (3) a similar solution lacking potassium; (4) one lacking phosphorus; (5) one lacking magnesium; (6) one lacking sulphur; (7) one lacking calcium; and (8) one lacking iron. All these solutions were prepared with distilled water from a Barnstead "still." Six pine seedlings (in two jars containing three seedlings each) were grown in the greenhouse under normal light conditions and under each nutrient condition for 222 days. At the end of this period, the seedlings were removed from the jars, and the tops and roots of each were observed and measured; they were then dried to constant weight in an oven at a temperature of 45 to 50° C., and weighed.

Results

Data from this study are given in table 1. The results are discussed below, and the most characteristic symptoms in each case are underlined. Figure 1 shows typical seedlings from each nutrient solution and supplements the tabulated data and the discussion.

All minerals present: full nutrient solution

As might be expected, the seedlings growing in this solution had the greatest total dry weight, the most lateral roots, and the longest and the most needles. The taproots were considerably shorter than those of the seedlings growing in some of the other solutions, but all of the roots were sturdy, thick, and profusely branched. On a few roots some lenticels were in evidence, but these apparently did not reduce the vigor of either the roots or the tops. Mycorhiza were particularly evident on the roots of each of the seedlings in this solution. Most of the fascicles contained three needles. The seedlings showed a healthy green color and vigorous growth throughout the experiment.

Solution lacking phosphorus (-P)

The total dry weight of the seedlings was somewhat less than that of the seedlings in the full nutrient solution. The needles were not quite so long as those in the solutions lacking magnesium and calcium, but they were more numerous. The taproots were somewhat shorter than those in the solutions lacking potassium, magnesium, and calcium, but the lateral roots were more numerous. Externally, the absence of this element did not exhibit any evidence of injury. The seedlings possessed normal green color throughout the experiment. All survived and only those in the full nutrient solution were more vigorous. Also fewer fascicles had three needles in the solution lacking phosphorus than in the full nutrient solution.

Table 1.--Effect of nutrient deficiency on the development of longleaf pine seedlings.[1]

Nutrient solution	Average dry weight				Root		Fascicles (needles)		Survival	Vigor	Average pH of solution
	Root	Top	Total	Ratio top:root	Average length	Average number of laterals	Average length	Average number			
	---------- Gm. ----------				Cm.		Cm.		Percent	Class[2]	
Full	0.559	1.421	1.980	2.6:1	13.7	35	27.4	13	100	A	5.73
-P	0.466	1.050	1.516	2.3:1	20.3	25	19.6	10	100	B	6.14
-Ca	0.305	1.020	1.325	3.3:1	21.1	19	23.1	7	67	C	6.14
-S	0.290	0.816	1.106	2.8:1	16.3	15	21.3	7	100	B	6.21
-N	0.426	0.562	0.988	1.3:1	35.6	23	18.3	5	100	C	5.45
-Mg	0.147	0.647	0.794	4.4:1	24.1	14	21.1	7	83	D	6.06
-K	0.181	0.546	0.727	3.0:1	22.9	17	11.9	4	50	E	5.98
-Fe	0.117	0.396	0.513	3.4:1	13.2	10	16.8	4	83	D	6.28

[1] Arranged in order of decreasing dry weight.

[2] Explanation of vigor class:
A = very vigorous; 3 needles per fascicle; color, deep green.
B = vigorous; 2 and 3 needles per fascicle; color, green.
C = weak; 2 and 3 needles per fascicle; color, pale green.
D = weak; 2 and 3 needles per fascicle; color, yellow to pale green.
E = very weak; mainly primary needles; color, bluish green; very few fascicles.

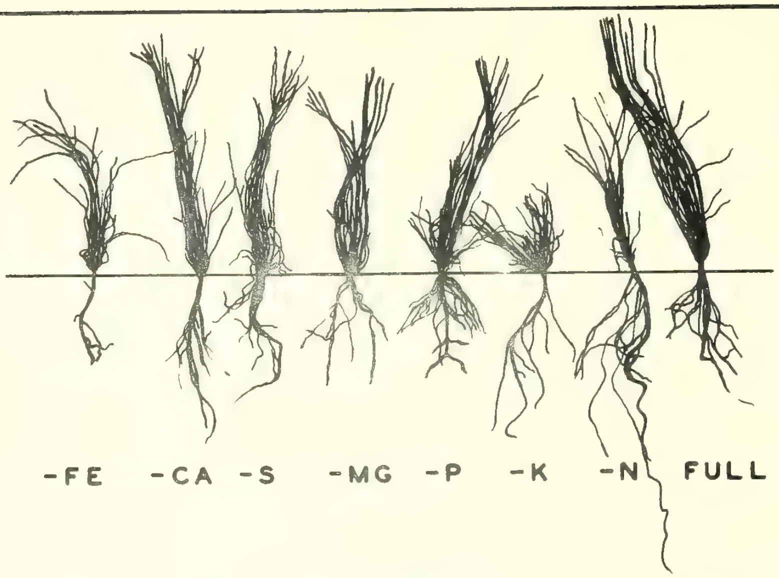

FIG. 1 : TYPICAL SEEDLINGS, SHOWING EFFECTS OF NUTRIENT DEFICIENCY.

Solution lacking calcium (-Ca)

During the first few weeks after establishment, the plants in this solution were very vigorous; the needles possessed a healthy green color and seemed to compare favorably with those growing in the full nutrient solution. Two months after establishment, however, growth apparently ceased, and an unhealthy pale color appeared in the needles followed by a reduction in the turgor, resulting in delicate, weak needles that had to be supported by a wire frame. At the end of 4 months, one of the six seedlings was dead and the rest were yellow-green and delicate. At the end of the experiment, two of the six seedlings were dead; the rest were yellow-green and spindly, and some needles were brown at the tips. The early, vigorous growth of the needles probably accounts for the relatively high weight of the tops. The weight of the roots, however, was low. In average length the needles ranked next to those in the full nutrient solution, but their number was only about half that of the seedlings in the full nutrient solution. The taproots were fairly long, and the number of lateral roots compared favorably with those in other solutions, but both taproots and lateral roots were delicate and densely covered with lenticels.

Solution lacking sulphur (-S)

These seedlings showed average dry weights somewhat lower than those growing in the solution lacking calcium. The needles averaged somewhat shorter than those of the seedlings lacking calcium, but were longer than all others except those of the seedlings in the full nutrient solution. The average number of fascicled needles was the same as in the solutions lacking magnesium and calcium. The taproots were shorter than those in most other solutions, but longer than those in the full nutrient solution and in the solution lacking iron. The number of roots was greater than in the solutions lacking magnesium and iron. All of the seedlings in the solutions lacking sulphur survived and showed no marked harmful deficiency effects. The needles were a healthy green, but they were also thin and spindly.

Solution lacking nitrogen (-N)

The seedlings began to show the effect of the absence of nitrogen two months after planting, and by the end of the experiment the needles were mostly pale green in the lower half and light brown from the middle to the tip. The lack of this element also expressed itself in the small number of needles; only those plants in the solutions lacking potassium and iron had fewer fascicles. All of the seedlings in this solution survived but they were delicate and sickly. The roots were long and covered with numerous lenticels, but were associated with few mycorhiza.

The amount of nitrogen necessary for the normal development of longleaf pine seedlings is apparently not very high. For several weeks after the experiment started it was difficult to detect any differences between the appearance of the seedlings growing in the full nutrient solution and that of the seedlings lacking nitrogen.

Solution lacking magnesium (-Mg)

The lack of magnesium was partially expressed in the very low dry weight of the roots. The needles were longer than those of plants in the solutions lacking potassium and nitrogen, but the tips of the needles turned brown early and the seedlings became pale green or yellowish and very weak or sickly. The taproots of the seedlings were long, but there were few lateral roots. Corkiness of the roots was not noticeable. One of the six seedlings died, and the survivors showed definite symptoms of weakness, expressed mainly in the color of the needles.

Solution lacking potassium (-K)

The seedlings showed a stunted, sickly condition from the very beginning and developed only a few, short, fascicled needles. At the end of the experiment these few fascicled needles were bluish-green except for their tips, which were dark brown or almost black. Most of the single needles were in the primary phase, bluish-green, short, and stout, but lacked brown tips. The needles were shorter and fewer than in any of the other solutions. Although three of the six seedlings died, and the survivors showed a very low vigor, the lack of potassium did not seriously affect the development of the taproot. The roots ranked third in length as compared with the roots in the other solutions, and the seedlings ranked fifth in number of lateral roots.

Solution lacking iron (-Fe)

The lack of iron began to have a visible effect within a month, and by the end of the experiment one of the six seedlings was dead and the rest were chlorotic and very weak. The surviving seedlings showed the lowest average dry weight recorded in the entire study. All of the surviving seedlings were pale yellow or almost white, weak, and spindly. The roots were decidedly corky, which was also true of the roots of the poor seedlings in the solution lacking potassium. Both the length of the taproot and the number of lateral roots were less in the solution lacking iron than in any other solution.

Summary and Conclusions

A preliminary study was made of the effects of the deficiency of seven essential mineral nutrients on the growth and development of longleaf pine seedlings. Knowledge of such effects is especially useful in a nursery, since correct diagnosis of soil-nutrient deficiencies must be made before the necessary remedial treatments can be applied.

The seedlings were three weeks old at the beginning of the experiment and were grown for 222 days in a four-salt full nutrient solution containing seven essential nutrients and in seven nutrient solutions lacking, respectively, nitrogen, phosphorus, potassium, sulphur, magnesium, calcium, or iron.

The absence of each of these elements produced definite symptoms. In the full nutrient solution most of the fascicles contained three needles, the foliage had a healthy green color, and the plants were vigorous. In the solution lacking phosphorus the needles also showed a healthy green color, but many of the fascicles contained only two needles. In the solution lacking calcium, the seedlings were pale green and spindly, and some needles were brown at the tips. In the solution lacking sulphur, the needles had a healthy green color but were thin and spindly. In the solution lacking nitrogen, the needles were pale green and delicate, and they were less numerous than in any other solutions except those lacking potassium and iron; many were brown from the tips down to the middle. In the solution lacking magnesium, the needles were pale green or yellowish and all had brown tips. In the solution lacking potassium, the few fascicled needles were bluish-green except at the tips, which were dark brown or almost black. Most of the single needles were in the primary phase, bluish-green, short and stout, but without the brown tips. In the solution lacking iron, the needles were pale yellow or almost white, weak, and spindly.

The poorest growth and the lowest dry weight occurred in the solutions lacking potassium and iron. The best growth and the greatest dry weight occurred in the full nutrient solution and in the solution lacking phosphorus. Mycorhiza were most numerous on the most vigorous seedlings.

A comparison of the vigor of the pine seedlings in the different solutions indicates that those which are supplied with all the essential mineral elements are the most vigorous and show the best growth and development. Although the seedlings growing in solutions lacking phosphorus and sulphur were not quite as vigorous as those in the full nutrient solution, apparently the natural requirement of the pine seedling for these salts is not very high, especially for phosphorus, for under natural conditions longleaf pine inhabits soils notably poor in phosphorus. Also the seedlings growing in solutions lacking nitrogen and calcium were somewhat less vigorous than the seedlings supplied with all the necessary elements, but here again it is evident that the requirement for calcium and nitrogen must not be very high, for these salts are not readily available in the soils inhabited by longleaf pines.

Especially poor vigor was shown by the seedlings growing in solutions lacking magnesium, iron, and potassium. These salts are evidently very essential to longleaf pine, and the natural soils inhabited by this species contain an abundance of iron and potassium; although the latter salt is not readily available to crop plants, it is apparently available to pines in adequate quantities, for under field conditions potassium starvation seldom occurs. Furthermore, it is often noted that on freshly burned-over land longleaf pine seedlings appear especially green and vigorous after recovering their foliage. It is possible, judging from this study, that the ashes left on the surface of the soil may produce a temporary increase in salts normally not very available and thus stimulate the growth of the seedlings.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
SOUTHERN FOREST EXPERIMENT STATION

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R - SS
Reports
Occasional Paper No. 65

July 20, 1937

Dear Sir:

Poor growth of longleaf pine seedlings in the nursery or in the field may be due to any one or more of a number of different causes. Deficiency of specific mineral nutrients is often suspected in such cases but has seldom been definitely proved or disproved. The reason for this is the lack of knowledge of the symptoms caused by different mineral deficiencies.

A preliminary study to supply this information was recently undertaken at this Station. The findings are given in the enclosed progress report. Knowledge of the effects of soil-nutrient deficiencies is especially useful in forest nurseries, since correct diagnosis must be made before the necessary remedial treatments can be applied.

Potassium and iron were found to be especially essential to the proper development of longleaf pine seedlings. Phosphorus seemed to be the least essential of the seven minerals studied. Nitrogen, so important to most agricultural crops, ranks only fourth in apparent importance. More comprehensive studies in this field are planned for the future, but it is thought that the findings of this preliminary study will prove useful to foresters and nurserymen.

Very truly yours,

E. L. Demmon

E. L. DEMMON,
Director.

Enc.

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OCCASIONAL PAPER No. 66 August 9, 1937

SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director,

New Orleans, La.

FOREST INDUSTRIAL EXPANSION IN SOUTHEAST TEXAS - POSSIBILITIES AND DANGERS

by

Robert K. Winters, Forester

This paper releases data gathered in current investigations at the Southern Forest Experiment Station, and is subject to correction or modification following further investigation.

FOREST INDUSTRIAL EXPANSION IN SOUTHEAST TEXAS - POSSIBILITIES AND DANGERS [1]

By Robert K. Winters, Forester,
Southern Forest Experiment Station.

We see a great deal in the press these days about the conservation of natural resources. Oil, gas, coal, sulphur, forests, and game are frequently spoken of in the same breath without distinction. As a matter of fact, these natural resources fall into two distinct classes - nonreplaceable resources and renewable resources. Oil, gas, coal, and sulphur are examples of the former; forests and game are examples of the latter. These two classes of resources differ in that the renewable resources can be propagated by man within a comparatively short period, whereas the nonreplaceable resources require geologic ages for their formation.

Wise use of any renewable resource involves the consumption each year of only the annual accretion, leaving the growing capital intact. For example, no producer of beef cattle who expected to continue in business would consider selling all, or even 90 percent, of his herd. Rather, he maintains a herd of nearly constant size by selling practically all of his 2-year-olds and only the oldest of his breeding cows.

The forest resource is the raw material for certain industries supplying essential needs of men in the form of manufactured products and of income to both employers and employees. The ability of the forest resource in any locality to meet the continuous needs of the industrial plants drawing from it should be a very important factor in determining the location of new plants. Serious mislocation of plants with respect to continuing timber supplies is not only wasteful of capital, but because it results in migratory populations is also unsatisfactory from the standpoint of community development.

I have shown in the chart (fig. 1) the location of the existing and definitely projected pulp mills in the South. In all, 44 plants are shown. Of these, 11 are either still under construction or have been operating less than 18 months. After study of this chart, you may ask, "Were these new plants located after careful consideration of the ability of the forest to meet the needs of the proposed plants in addition to the already established forest industries?" I think the answer is, "No." As a matter of fact, Forest Survey data for southeast Georgia indicate that there is a serious threat of overcutting the forest after all the pulp mills now proposed swing into full production. This means that eventually some of the forest industrial plants will have to cease operation on account of lack of wood, and employees of these plants will have to seek employment elsewhere.

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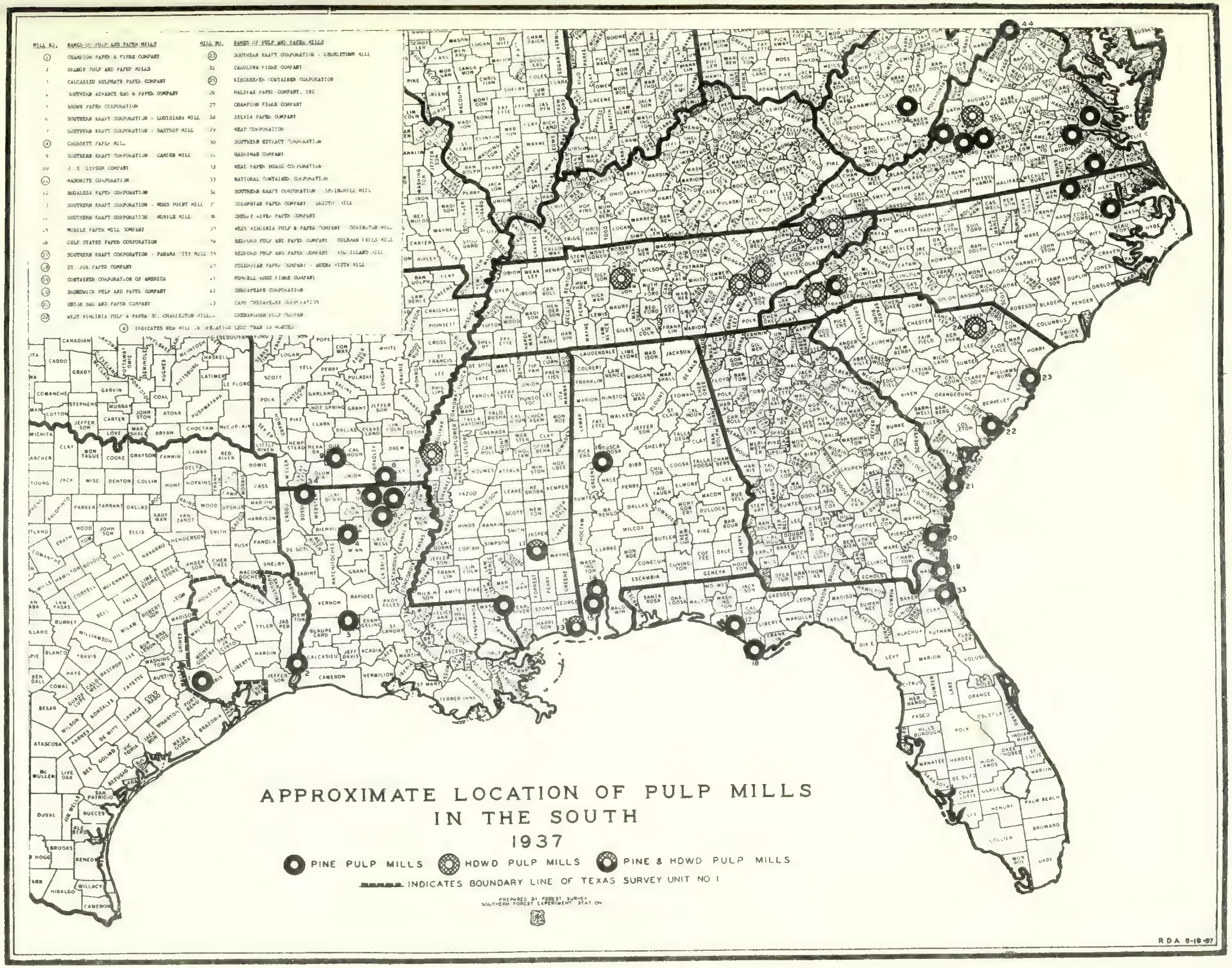
[1] Address delivered at Beaumont, Texas, before the Texas Academy of Science, June 26, 1937.

I hear that several locations in eastern Texas are being actively promoted as desirable sites for new pulp mills. What is the permanent producing power of your forests? And what is the nature and size of the existing industrial structure depending upon these forests for basic raw materials? The answer to these two key questions will go far toward determining the extent and the kind of safe forest-industrial expansion.

For the remainder of my discussion I shall confine myself to the area in southeast Texas bounded by the heavy black line (see fig. 1). This area comprises nearly 10 million acres. Approximately two-thirds is forested, and 13 percent is actually under cultivation. The timber volume on this forest area by the International $\frac{1}{4}$-inch log rule, which closely approximates green lumber tally, is $19\frac{1}{2}$ billion board feet, equivalent to nearly 85 percent of the total cut of lumber in the entire United States in 1936. This volume is in pine and cypress trees 9.0 inches and larger in diameter and in hardwood trees 13 inches and larger in diameter. The total volume on this forest area, expressed in cubic measure is $7\frac{1}{2}$ billion cubic feet. This cubic volume is in sound trees 5.0 inches and larger in diameter and includes the upper stems of pines and the upper stems and limbs of hardwoods to a 4-inch minimum limit. This timber volume, more than half pine, corresponds to the "herd" of the stock-raiser. It includes the calves, the 2-year-olds about to the sold, and the breeding stock. Safe industrial development will use only the accretion, maintaining the forest capital intact just as the stock-raiser markets only the increase in his herd.

To return to the first of our two key questions mentioned above: "What is the yearly accretion on this forest growing stock?" Or in other words, "How much can be cut each year without reducing its volume?" Figure 2 shows graphically for 1935 the total board-foot and cubic-foot forest increment classified as pine and hardwood and the corresponding forest drain. The pine increment was approximately 1 billion board feet or 272 million cubic feet, while pine drain against the forest was 618 million board feet or 128 million cubic feet. The hardwood increment was 264 million board feet or 121 million cubic feet, while the hardwood drain was 196 million board feet or 64 million cubic feet. Thus in 1935 the growth is seen to have been considerably in excess of the drain in both board feet and cubic feet. It is estimated that the 1936 drain was 18 percent greater than 1935, and the 1937 drain may possibly be 10 to 12 percent greater than the 1936 drain.



APPROXIMATE LOCATION OF PULP MILLS IN THE SOUTH

1937

● PINE PULP MILLS ◎ HDWD PULP MILLS ◎ PINE & HDWD PULP MILLS

▬ INDICATES BOUNDARY LINE OF TEXAS SURVEY UNIT NO I

PREPARED BY FOREST SURVEY
SOUTHERN FOREST EXPERIMENT STATION

RDA 8-19-37

MILL NO.	NAMES OF PULP AND PAPER MILLS	MILL NO.	NAMES OF PULP AND PAPER MILLS
①	CHAMPION PAPER & FIBRE COMPANY	㉓	SOUTHERN KRAFT CORPORATION - GEORGETOWN MILL
2	ORANGE PULP AND PAPER MILLS	24	CAROLINA FIBRE COMPANY
3	CALCASIEU SULPHATE PAPER COMPANY	㉕	KIECKHEFER CONTAINER CORPORATION
4	SOUTHERN ADVANCE BAG & PAPER COMPANY	26	HALIFAX PAPER COMPANY, INC
5	BROWN PAPER CORPORATION	27	CHAMPION FIBRE COMPANY
6	SOUTHERN KRAFT CORPORATION - LOUISIANA MILL	28	SYLVIA PAPER COMPANY
7	SOUTHERN KRAFT CORPORATION - BASTROP MILL	29	MEAD CORPORATION
⑧	CROSSETT PAPER MILL	30	SOUTHERN EXTRACT CORPORATION
9	SOUTHERN KRAFT CORPORATION CAMDEN MILL	31	HARRIMAN COMPANY
10	J S GIPSON COMPANY	32	MEAD PAPER BOARD CORPORATION
⑪	MASONITE CORPORATION	33	NATIONAL CONTAINER CORPORATION
12	BOGALUSA PAPER CORPORATION	34	SOUTHERN KRAFT CORPORATION SPRINGHILL MILL
13	SOUTHERN KRAFT CORPORATION - MOSS POINT MILL	35	COLUMBIAN PAPER COMPANY BRISTOL MILL
14	SOUTHERN KRAFT CORPORATION MOBILE MILL	36	CHERRY RIVER PAPER COMPANY
15	MOBILE PAPER MILL COMPANY	37	WEST VIRGINIA PULP & PAPER COMPANY COVINGTON MILL
16	GULF STATES PAPER CORPORATION	38	BEDFORD PULP AND PAPER COMPANY COLEMAN FALLS MILL
⑰	SOUTHERN KRAFT CORPORATION - PANAMA CITY MILL	39	BEDFORD PULP AND PAPER COMPANY BIG ISLAND MILL
⑱	ST JOE PAPER COMPANY	40	COLUMBIAN PAPER COMPANY - BUENA VISTA MILL
⑲	CONTAINER CORPORATION OF AMERICA	41	HUMMEL ROSS FIBRE COMPANY
⑳	BRUNSWICK PULP AND PAPER COMPANY	42	CHESAPEAKE CORPORATION
㉑	UNION BAG AND PAPER COMPANY	43	CAMP CHESAPEAKE CORPORATION
㉒	WEST VIRGINIA PULP & PAPER CO. - CHARLESTON MILL	44	SHENANDOAH PULP COMPANY

⑧ INDICATES NEW MILL IN OPERATION LESS THAN 15 MONTHS

Figure 1

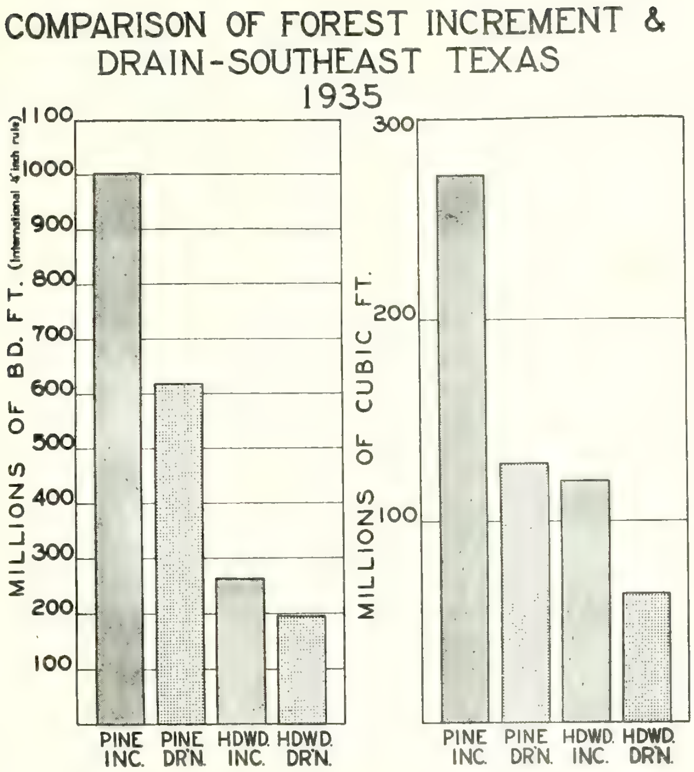


Figure 2

And now to the second of our key questions: "What is the nature of the forest industry that was responsible for the cutting of this timber?" In figure 3 is shown the approximate location of the larger forest industrial plants in southeast Texas. In all, 63 of the larger sawmills are shown (there being 112 additional small ones not shown), 4 veneer plants, 4 creosoting plants, 1 stave mill, 2 pulp mills, and 10 other miscellaneous wood-using plants.

In the light of the answers to these two key questions there is plainly an opportunity for expanding the forest industries in southeast Texas without risk of materially reducing the forest capital or growing stock. Even though the present forest industries increase production in 1937 as much as 30 percent over their 1935 production and hold this level for the next few years, there still would be sufficient timber growth to justify some expansion in wood-using industries. The question naturally arises, from the point of view of the long-time welfare of the people and communities of this area, "Should more pulp mills be built, more new sawmills be constructed, or should the timber consumption of other kinds of forest industrial plants be increased?"

A sound answer to this question hinges on a consideration of the following three points:

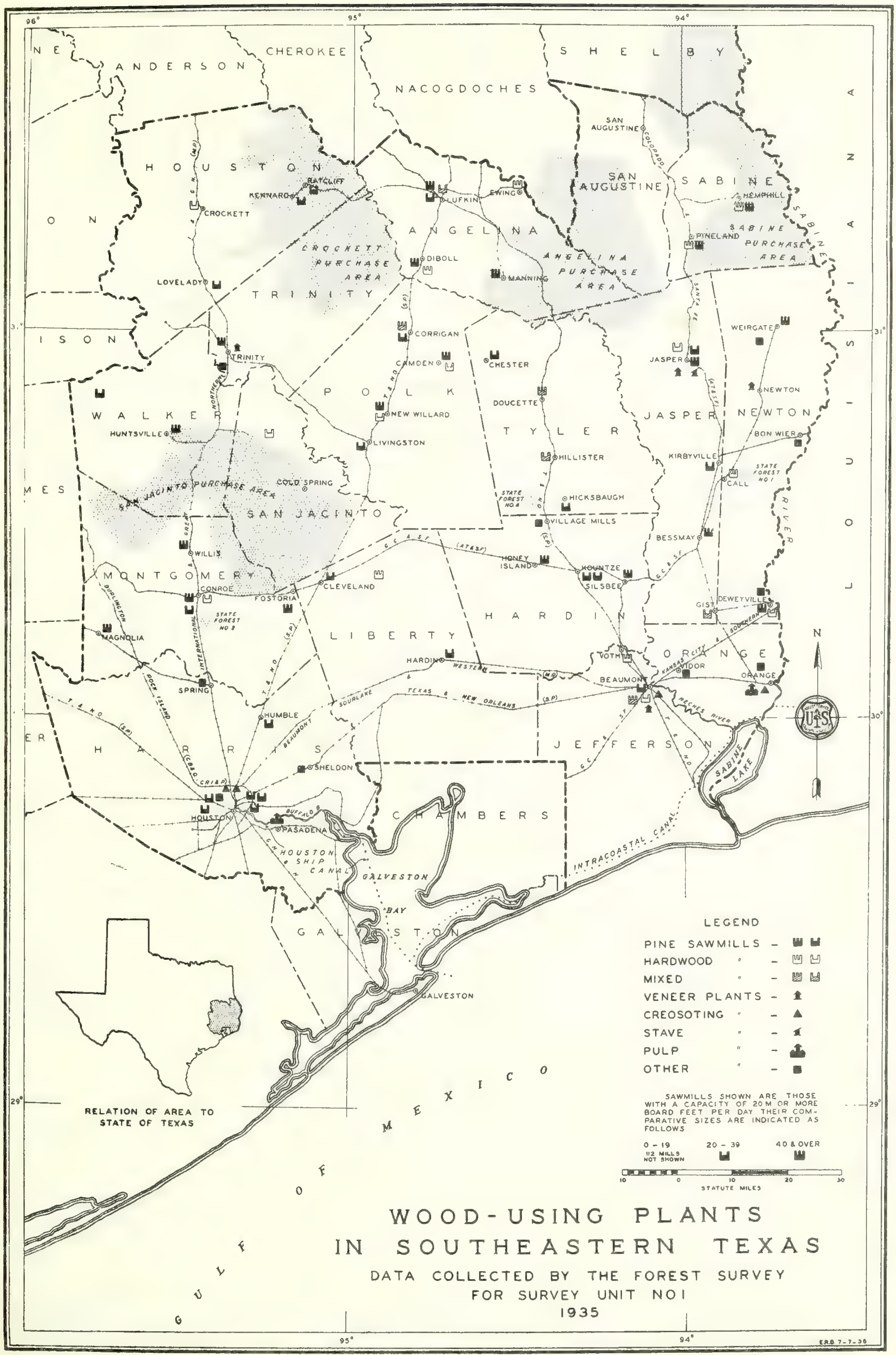
1. The comparative stumpage value per unit of wood volume of pulpwood, sawtimber, poles, veneer blocks, etc. Making this comparison is an aid in measuring the relative economic advantage in growing wood for pulpmills, sawmills, poles, veneer, etc.

2. The amount of labor required to manufacture a unit volume of wood into paper, lumber, veneer, etc. Industries requiring a large expenditure of labor per unit of volume of product are, other things being equal, more valuable as community builders.

3. The value added through manufacture of a unit volume of wood into paper as compared with the value of an equal volume of wood when made into lumber or other products. In general the greater the value added through manufacture, the greater will be the sum of money distributed in wages, purchase of supplies, plant maintenance, interest on investment, and dividends.

I shall develop each of these in turn, comparing items for lumber and paper production.

Present stumpage prices for pulpwood if purchased by the cord are usually quoted at 50 to 75¢ per standard cord in this area. (The U. S. Forest Service is asking $1.00 per cord for pulpwood from the National Forests in the South.) On the basis of 77 cubic feet of solid peeled wood per cord this wood is worth about 2/3 to 1¢ per cubic foot of peeled wood. Comparable stumpage prices for good pine sawtimber at $5.85 per M board feet is 3½¢ per cubic foot. Accordingly, wood marketed for pulp sells for only 1/5 to 1/3 as much per unit of volume as when grown to a size and quality suitable for the manufacture of the better grades of lumber. Furthermore, most pulpwood is cut from trees less than 13 inches d.b.h. and at a stage in their development when they are probably making their most rapid growth. Thus pulpwood operators, cutting chiefly young timber, are removing trees at a time when they are about to make rapid growth and when their value per unit of volume under present conditions is relatively low. From the point of view of the average timberland owner, therefore, the growing of wood for pulp manufacture alone does not yield the maximum possible money return per unit of volume grown.



SOUTHERN FOREST EXPERIMENT STATION - NEW ORLEANS, LA

Figure 3

In the South, it is estimated that for an average mill approximately three 10-hour man-days are required to manufacture 1,000 board feet of standard, dressed, pine lumber. This labor requirement includes the employment necessary in cutting the logs in the woods, transporting them to the mill, sawing them into lumber, and drying and surfacing the lumber. Expressing this in terms of cubic contents, we find that the lumbermill labor requirement is 13.5 man-hours per standard cord (4 x 4 x 8 ft.) of wood with bark, containing 77 cubic feet of peeled wood. In contrast, the corresponding labor requirement of the southern pulp industry is estimated at 17 man-hours per standard cord. This includes the cutting and transporting of the billets to the pulp mill and the manufacturing of the pulp and kraft paper or paper board. It is apparent, therefore, that the wood-pulp industry uses more labor per unit of wood consumed than does the pine-lumber industry.

The current market price of southern pine lumber (average of all grades) is in the neighborhood of $32 per M board feet. If we assume that average second-growth pine stumpage sells at $3 per M board feet, this leaves $29 as the value added through manufacture. Converting this to standard cords, this is approximately $13 per cord. Assuming a stumpage price of 50¢ a standard cord for wood and an average current price for southern kraft paper of $95 per short ton (f.o.b. mill) and further assuming 1.5 standard cords of wood and bark per ton of kraft paper, the value added to a standard cord of wood by converting it into this type of paper is $62.83. Thus we see that the value added to the cost of wood in the manufacturing of kraft paper is about five times as great as the value added in the manufacture of pine lumber. This money is spent for wages, improvements in plants, interest on invested money, and dividends. Some part of it is spent locally, contributing to the support of grocers, clothiers, carpenters, and others; probably a smaller percentage is spent locally than in the case of the sawmill operation under consideration.

Comparing only the wood pulp and the lumber enterprises we find that for the same unit of volume the value of high-grade sawmill stumpage is greater than that of pulpwood stumpage, although paper manufacture requires a greater expenditure of labor and adds a greater value through manufacture. It is apparent, therefore, that each has advantages and that each can play an important part in the industrial life of a community. The question might be raised, "Are they hostile industries, competing in the same market for the same kind of wood?" The answer is: "Ordinarily they are not, but under pressure of need, pulp mills can cut the trees over a large area before they reach a size that makes them attractive to the lumber mill and thus force lumber mills out of the territory." There is a way, however, that each can be made to further the best interest of the other and to work together for the good of all.

The production of clear lumber requires that young timber stands be dense. Fastest growth on the trees that are ultimately to be harvested for lumber can be obtained only by thinning these dense young stands at proper intervals. Four or five of these thinnings may be made to yield pulpwood during the time that the final crop of sawlog-size trees is maturing. Cuttings of this kind in Europe indicate that the volume produced in periodic thinnings needed to grow a stand of pine trees to an average d.b.h. of 15 inches is about equal to the volume removed in the final harvest of sawlog-size trees. This means, for example, that if a stand in the South treated after this fashion yields 12,000 board feet per acre at the end of 50 years, it probably would have yielded during this period 25-30 cords of pulpwood per acre in thinnings.

Furthermore, in all stands there are defective, crooked, and partially rotten trees that ought to be cut and be replaced by good, thrifty seedlings. As a rule these defectives can be used as pulpwood with resulting improvement to the growing condition of the stand. In addition, generally some part of the tops of trees cut for sawlogs can be utilized for pulpwood.

Thus we see that it is definitely possible to integrate the pulp and paper industry with the industries already existing. On the other hand, there is the very real possibility that some pulp mills will cut chiefly thrifty, rapid-growing, young timber when it is about to enter its most productive stage, thus preventing the development of the high-grade raw material upon which other industries must depend.

These are the two extremes of pulpwood utilization possible throughout the southern pinelands. The successful handling of the situation requires, it seems to me, the organized effort of such groups as the Texas Academy of Science. This effort should follow two channels: (1) educating landowners, both large and small, in better ways to handle their woodlands in order to secure maximum growth and income through producing sawtimber, poles, piles, naval stores, and other forest products, along with their pulpwood; and (2) arousing public opinion to the point where it will insist that the establishment of pulp and other forest industrial plants be based on the ability of the forest to support them continuously. The Southern Forest Experiment Station will publish in the near future a comprehensive report on southeast Texas showing in detail the timber-growth possibilities of this area and the requirements of present industries. This report will be invaluable in planning wisely for the full and longtime use of the forest resources of the region.

Today, the outlook for forest industries in southeast Texas is indeed bright. You have a splendid, fast-growing, pine forest with a fairly well-balanced industry drawing upon it. A few more well-located pulp mills, properly utilizing the forest thinnings and tops of sawlog-size trees should improve the present industrial structure. On the other hand, too many pulp mills improperly placed and cutting young timber indiscriminately could go far toward destroying the valuable forest resource upon which some of your most important industries depend. In the end, it will be your problem, as East Texans, to determine what you will do. Will you handle your resources so that your industrial development will bring you permanent forest industries with all the privileges and values that accompany a stable community, or will your industries be merely temporary ones that will operate for a few years, deplete your forests, and then move to virgin territory, leaving behind as a public liability a stranded and destitute population with insufficient opportunity for employment and no hopeful outlook for the future?

OCCASIONAL PAPER No. 67 August 23, 1937

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE WORK OF THE SOUTHERN FOREST EXPERIMENT STATION AND ITS APPLICATION TO PRIVATE FOREST MANAGEMENT

by

W. E. Bond, Senior Forest Economist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

THE WORK OF THE SOUTHERN FOREST EXPERIMENT STATION AND ITS APPLICATION TO PRIVATE FOREST MANAGEMENT [1]

By W. E. Bond, Senior Forest Economist,
Southern Forest Experiment Station.

It is not my purpose to report to you on all of the research work done at the Southern Forest Experiment Station. This would be impossible in the time allotted to me, and you would not be interested in all of it. If you are interested in a report of all of the work, I would refer you to our last annual report, which will be gladly sent to you upon request. I should like to grasp this opportunity, however, to report to a group of landowners who think enough of their timber to spend money in protecting it from fire, the results of our investigations as they apply to practical and profitable forest management.

First of all, for the benefit of some of you who may not know about the Southern Station, let me say that we have our headquarters at New Orleans but carry out most of our forestry investigations on eight experimental forests in various parts of our territory between Texas and the Atlantic Ocean. Two of these forests are in Arkansas, one at Crossett, and the other on the Ouachita National Forest; two more are in Mississippi; two are in Florida; one is in Louisiana; and one is in Texas.

Since the territory includes eight States and many different forest types, sites, and conditions, the investigations of the Southern Forest Experiment Station must cover practically the whole field of forestry and many allied fields. To give you a picture of the work of our Station, allow me to point out very briefly the different divisions of research and the work covered by each. There are four divisions, namely, Silvics, Forest Influences, Economics, and Forest Survey. In addition there are three other cooperating agencies of the Department of Agriculture, namely, the Bureau of Plant Industry, the Bureau of Entomology and Plant Quarantine, and the Bureau of Biological Survey.

The Division of Silvics is the oldest, and many people still think of the Station as including only this division. Investigations in this division include studies of seed; nursery practices; planting; fire damage, behavior, and control; naval stores; thinning; pruning; stand improvement; natural reproduction; methods of cutting merchantable stands; volume tables; growth and yield of different tree species; and fundamental studies of forest soils, the physiology of different tree species, and the interrelationships of trees and their environment. These various studies supply the basic data for practical forest management. They determine underlying causes, measure effects, and seek to determine or develop the best practices. Since such studies are usually made on relatively small sample plots, where every factor can be accurately determined, reliable data on costs and returns usually cannot be obtained.

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[1] Address delivered at The Second Annual Meeting of Arkansas State Forestry Commission Cooperators at Little Rock, Ark., July 6, 1937.

The Division of Forest Influences is studying effective and practical methods of rehabilitating deteriorated watersheds, and of safeguarding watershed values through the practice of forestry. Studies are also made of the influence of forest and other plant cover on run-off, evaporation, and groundwater storage.

Investigations in the Division of Economics include studies of the financial aspects of private forestry, forest taxation, and land use. These studies apply the results of the Silvics investigations and, through studies of logging, milling, and applied forest management, determine economic practicability and possibilities of profits. They are made on relatively large areas, using commercially feasible practices, and results are therefore applicable to the management of entire forest properties.

The Forest Survey is making an inventory of the extent, location, and condition of forest lands; the quantity, kinds, quality, and availability of the timber now standing on these lands; the rate of drain through cutting, fire, insects, disease, and other causes; the current and probable future rate of timber growth and the productive capacity of the forest area; and the present and probable future need for forest products in the different parts of the country by all classes of consumers. It also includes an analysis of the relations of these findings to one another and to other economic factors, as a basis for the formulation of policies and principles of forest-land utilization. It involves both field inventories and the compilation of data from many sources. The results obtained do not apply to definite properties but to larger areas such as States or relatively large portions thereof and to the South as a whole.

The cooperating agencies are studying the relationships of fungus diseases, insects, and wild life to forests and forest products. Often problems arise which, although outside the field of forestry, may seriously affect forestry practices - as, for example, the relationship of pine bark beetles to selective cutting.

And now what has research found out that you as forest landowners can use here in Arkansas? Let us forget about Station divisions and consider only those investigations from the Southern Station which contribute results usable in practical forest management. Although we do not yet know all the refinements of management, I think that from results of our research work we are now in a position to recommend the practices desirable in sustained-yield management and give you approximate costs and returns.

To make this more concrete, I suggest that we consider these investigations as they would apply to a definite property of 50,000 acres made up chiefly of second-growth stands of loblolly and shortleaf pine cut over at various periods up to 25 years ago and with about 10 percent of the area in old-field stands of various ages from reproduction up to sawlog size. If this area has typical second-growth timber, it is understocked, and the cut should be held to less than the growth until the growing stock has been built up.

In placing a forest property under management, the first consideration is adequate fire protection. I am sure that State Forester Gillett can tell you more definitely than I what is "adequate" fire protection, but I should say that the area burned annually over a period of years should average less than 1 percent of the total area. Our studies have shown that there is no place for fire in the loblolly and shortleaf pine type; that fire destroys reproduction and may do serious damage to mature trees under certain conditions. I believe that at present fire protection costs forest owners about 2¢ per acre, and that the State and Federal Governments match this amount.

The next task in placing a forest property under management is to determine approximately the amount of growing stock and the growth for the property as a whole, in order to arrive at the allowable cut under sustained-yield management. Often an estimate of the merchantable timber is already available but, if not, this can be determined by a line-plot survey, running a line through the center of each section and tallying the merchantable timber on 1/4-acre plots at 1/8-mile intervals. A crew of two men could cover a property of 50,000 acres in about 1 month. By adding a third man, measurements of growth of trees of various sizes could be determined. From these sample areas the amount of merchantable timber and the annual growth for the whole property can be determined within reasonable limits of error. Such a survey is inexpensive but is sufficiently accurate to arrive at the amount of cut that can be made without depleting the capital growing stock. Of course the growing stock and growth by sections or by forest types and conditions can not be determined by such a survey. When cutting is actually started on definite areas, then is the time to take a more intensive inventory of the cut and of the residual stand for those areas.

Our studies of applied forest management have convinced us that in our irregular, uneven-aged shortleaf-loblolly stands we should practice selective cutting, making light cuts at intervals of 5 to 10 years. Each cut should take no more than will be regrown before the next cut, and where possible some growth should be reserved and added to the growing stock if the stand is understocked. With a 10-year cutting cycle the cut on fairly good sites should seldom remove more than 45 percent of the stand, and with a 5-year cutting cycle not more than 25 percent should be removed. If economically feasible, lighter cuts of 35 and 20 percent, respectively, are preferable since they will enable the stands to build up more rapidly. If an inventory and growth study such as the one mentioned above is made, the actual allowable cut can be determined within reasonable limits of error.

Our logging studies have shown that the costs of selective logging with trucks, removing as low as 500 board feet per acre, are very little higher than when cuts as heavy as 3 or 4 M feet per acre are made. Costs of selective logging are actually lower than costs of clear-cutting, because the size of the average log is larger. This is also true of milling costs. The grades and values of lumber cut from larger trees are much higher than those cut from smaller trees. For example, the value per M feet for stumpage and profit, that is, the difference between the sale value of lumber and all costs of logging, milling, and selling, was found to be $1.43 for 12-inch trees, $4.73 for 16-inch trees, $8.00 for 20-inch trees, and $11.42 for 24-inch trees. Evidently selective logging should be practiced if greater profits and greater yields are desired over a long management period.

When cutting begins on a definite area, actual forest management begins, and the forest owner should devote much thought and effort in determining the allowable cut and most profitable outlets for the material removed. Cutting to rigid diameter limits has been tried out in the past but with little success. It is essential that an experienced technician select and mark each tree to be cut. To check his marking it is desirable to tally by diameter-classes all trees marked and also all sawtimber trees left for further growth. We have found that a crew of three or four men can mark and tally all of the sawtimber on 40 to 80 acres per day at a cost of not more than 10¢ per M feet of cut. In marking it is desirable to remove those trees which will not make satisfactory growth in volume, quality, or value between the present and the next cut. This includes old, financially mature trees as well as all crooked, defective, and low-quality trees of merchantable size. Of course the total cut on the areas selected for cutting must not exceed the volume which will grow back before the next cut, and it should be definitely less than this amount in order to build up the growing stock. By carefully marking the poorer trees the growth is shifted to the better trees, and the quality and value of the future growth is increased. By cutting trees of all diameters instead of only the larger ones the relative number of larger trees is increased and the productivity of the site is better utilized in growing merchantable material. Larger trees of high quality are of much greater value when cut into lumber, and also logging and milling costs are reduced. Greater profits are therefore returned to the owners from such management.

On our forest of 50,000 acres we assumed that we had a considerable area in old-field stands of different ages. In south Arkansas there is now a market for pulpwood, and pine trees above 5 inches d.b.h. can be utilized for this purpose. It is usually unprofitable to thin old-field stands until they are merchantable for pulpwood. Our studies have shown that 5-inch trees hardly pay for the cutting and hauling and that 6-inch trees yield very little profit. In fact it takes twice as long to cut a cord from 5-inch trees as from 13-inch trees. In thinning, we have found that the largest trees in young stands are generally very rough and are poor potential sawtimber, so that it is advisable to cut them and leave the cleaner, smaller trees to grow In order to maintain a high growth rate consistent with high quality, stands should be thinned before the crowns are very severely reduced through competition, occupying only the very tops of the stems. Too early or too severe thinning, however, will result in brushy low-quality timber. Thinning is advisable every 5 years if the best results are to be obtained, and should not be postponed under any circumstances for more than 10 years. We have found these thinnings to yield stumpage values of 50¢ to 75¢ per cord. The volume removed depends on the density and size of timber, but in many cases 10 cords per acre or more can be removed without overcutting. Before thinning, either the trees to be cut or the trees to be left (whichever is the less work) should be marked, but it is not necessary to tally either class of trees if the man doing the marking is an experienced technician. The cost of marking has been found to be about 2¢ or 3¢ per cord, but the benefit in leaving the most promising trees to grow into high-grade sawtimber very definitely justifies this expense.

On any large property we will also have second-growth stands which are not yet large enough for sawtimber. These areas bear many defective, crooked, and limby trees which will not increase in volume or value at a satisfactory rate; and some of these stands also need thinning. We have found that in typical understocked second-growth stands about 1 cord of pulpwood per acre can be removed in an improvement cutting. When there is a market for fuelwood or chemicalwood, a profitable cut of hardwood cordwood can also be made. The cost of marking, not including an inventory of the stand, amounts to between 3¢ and 4¢ per cord, but the stands after this cut has been made are left in a much better condition to grow high-quality sawtimber.

Another profitable practice, as shown by our studies, is the cutting of pulpwood from tops of felled sawtimber trees, from trees injured in logging, and from young trees marked to be removed to improve the density and quality of the stand. Such an operation, which should immediately follow logging, not only yields an income with which to pay taxes and other costs, but at the same time it assures increased growth of better timber in the future and reduces logging slash and the danger of forest fires. Our studies have shown that a stumpage value of at least 50¢ per cord remains after all costs are deducted from the selling price.

To summarize, the results of our investigations show that the following practices can be recommended to lumbermen and other owners of second-growth stands of loblolly and shortleaf pine.

1. Fire control that will limit the average area burned annually to less than 1 percent of the total area protected.

2. Thinning for pulpwood in dense young stands of old-field and second-growth timber, reserving the best-formed trees, properly spaced as basic growing stock for future development into high-quality sawtimber.

3. Improvement cutting for pulpwood or cordwood in second-growth stands which are wholly or largely unmerchantable for sawlogs, involving the gradual removal from all merchantable diameter-classes of trees that will not develop into high-quality material.

4. Periodic selective cutting at short intervals (5 to 10 years) in sawtimber stands, with each cut removing less volume than will be replaced by growth before the next cut, thus continually increasing the growing stock until it is sufficient for maximum production. As far as the felling budget will permit, the cut should be limited to trees financially mature because of size, poor condition, or low capacity for growth, in order to shift growth from trees of poor form and vigor to better trees. Within the limits of economic feasibility, the larger and more vigorous good trees should be included in the reserve stand so that as much as possible of the productivity of the site can be devoted to the growth of sawtimber of high quality and value.

5. Integrated utilization to the greatest extent consistent with available markets, providing for the highest and most profitable use of each tree and all portions of each tree. Pulpwood and cordwood should generally be produced from tops of sawtimber trees and from trees below sawlog size, removed as thinnings and improvement cuttings, and not from the portions of trees suitable for sawlogs.

Furthermore, I should like to point out that the studies made at th
Station are showing that the management of second-growth stands
and shortleaf pine and hardwoods is financially profitable. Suc
stands in southeastern Arkansas average per acre about 3,000 fee
(International 1/4-inch scale) of pine sawtimber (14 inches and
and 1,000 feet of rather poor-quality hardwoods (14 inches and m

besides considerable young growth. Studies show that these stands under sustained-yield management will yield at present values an annual gross income of from $1.00 to $1.75 per acre, depending on the management, growth, and economic conditions. Pine in these stands is growing in volume at a rate of about 7 percent compounded annually. Average stands of 3,000 feet b.m. of pine per acre, therefore, will grow during a 10-year period into stands containing 5,900 feet per acre or will grow at the average rate for this period of 290 feet per acre per year. Since even these stands of 5,900 feet per acre are understocked, the cut should not take all of the growth but should be limited to less than the growth, for example, to about 2,000 feet, leaving 900 feet for addition to the growing stock. Even this periodic cut is equivalent to an annual yield of 200 feet b.m. (30 cubic feet) per acre. In this same second-growth timber, the yield of pulpwood in cubic feet which can be cut from tops, thinnings, or improvement cuttings, at the end of the 10-year period, equals about two-thirds of the cubic-foot volume of the sawtimber cut. In such a case, with an annual yield of 30 cubic feet of sawtimber per acre, the additional yield of pulpwood is 20 cubic feet of solid wood (or 0.27 cord of stacked wood with bark) per acre per year.

At present, pine sawtimber stumpage ranges in value from $3 to $9 per M feet b.m. (2¢ to 6¢ per cubic foot), depending on size, quality, and location. At an average value of $6 per M board feet, the annual yield of 200 feet has a stumpage value of $1.20. The pulpwood yield of 20 cubic feet per acre per year with a stumpage value of 1¢ per cubic foot (75¢ per standard cord of 128 cubic feet) has a value of 20¢. The value of the annual yield of hardwoods is estimated at 15¢ per acre. Under these conditions, the gross income from total stumpage is $1.55 per acre per year. The total present cost of forest management including taxes, fire protection, technical services of a forester and assistants, general administration, etc., is estimated at 20¢ to 30¢ per acre per year.

After several cutting cycles under good management, these second-growth stands will be much better stocked with higher-quality trees, and yields will be correspondingly better both in volume and in quality. Measurements of volume growth in well-stocked second-growth stands indicate that the yield recorded above can be doubled when the stands are completely built up. It is estimated that costs, which may also increase (but not in the same proportion as income) may range from 30¢ to 50¢ per acre per year.

In conclusion I should like to invite you to visit any of the Station's experimental forests and, as lumbermen and forest owners in Arkansas, I extend to you a special invitation to inspect our work at Crossett. There you can examine the timber resulting from definite forest practices, and obtain the yields, incomes, and costs. There also you can inspect profitable sustained-yield forest management and integrated utilization as applied by large commercial operators.

I hope that I have made it clear that the results of our investigations are of practical use to those forest owners who wish to practice profitable sustained-yield forest management. We are gratified that an increasing number of owners of both large and small tracts of forest land are adopting the practices recommended, and we feel sure that as operators familiarize themselves with the principles of good forest management they will become progressively convinced of the fact that forest management pays.

OCCASIONAL PAPER NO. 68 SEPTEMBER 15, 193

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

FACTORS FOR CONVERTING LOG AND TREE VOLUMES OR VALUES FROM ONE COMMON SCALE TO ANOTHER

by

R. R. Reynolds, Associate Forest Economist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FACTORS FOR CONVERTING LOG AND TREE VOLUMES OR VALUES FROM ONE COMMON SCALE TO ANOTHER[1]

by

R. R. Reynolds, Associate Forest Economist,
Southern Forest Experiment Station.

Since trees are cut into many products, which are measured by any one of several log rules, by the piece or by cubic content, those who deal with forests or forest products have numerous occasions to convert log or tree volumes from one unit of measurement to another, or to convert the value or cost of a thousand board feet of logs or timber from Doyle scale to International ($\frac{1}{4}$-inch kerf) or Scribner scale. Also it is often desirable to know how many cubic feet or cords of pulpwood are equivalent to a thousand board feet of timber from trees of given diameters.

Because of the demand for information that will permit rapid calculations similar to those indicated, the following tables are given, based on the measurement of 500,000 board feet in 874 logs and 1,207 trees, measured by Doyle scale, Scribner scale, International scale, and in cubic feet. As is stated in the tables, the values and converting factors for the logs were based on 16-foot logs only, while the values and converting factors for trees were based on the portions of the trees actually used or merchantable, regardless of the lengths of logs cut.

Uses of table 1

1. If the diameter inside bark of a 16-foot log is given, one can read off directly the volume of the log in board feet by the Doyle, Scribner, or International scales, and also the volume in cubic feet.

2. If the log-scale volume of a 16-foot log is given in any one of the three scales or in cubic feet, one can read off directly the equivalent volume in the other measurement systems.

3. If the log volume of a 16-foot log is given, one can read off directly the diameter inside bark at the small end of the log.

4. If the cost is given of felling and bucking, or skidding and loading, etc., per M feet in the International scale, one can determine the cost per M feet in a different scale. Example: If the cost of felling and bucking per M feet International scale for logs with a top diameter of 12-inches inside bark or 97 board feet is 60¢, what is the corresponding cost for logs of the same size in Doyle scale? From table 1 the converting factor from International scale to Doyle scale for logs of this size is seen to be 0.6598. Then the cost of the felling and bucking in Doyle scale is equal to 60¢ ÷ 0.6598 or 91¢ per M feet.

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[1] From a study of selective logging in southeastern Arkansas.

5. If the cost is given of felling and bucking, etc., per M feet based on a scale other than International, one can determine the cost in the International scale by multiplying this cost by the proper converting factor, as given in the table. Example: If the cost of felling and bucking by Doyle scale is 91¢ per M feet for logs averaging 64 board feet per log, what is the corresponding cost in International scale? From table 1 it is seen that logs of this size have a converting factor of 0.6598. Then the cost of felling and bucking in International scale is 91¢ x 0.6598 or 60¢ per M feet.

6. If the cost is given of felling and bucking, etc., per M feet for logs of a given size based on either Doyle or Scribner, one can determine the cost in the other scale (Scribner or Doyle, respectively) by multiplying the value by the proper converting factor to obtain the value in the International scale, and then dividing by the converting factor for the size and log scale desired. Example: The cost of skidding and loading pine logs containing 100 feet log scale (Doyle) is 72¢ per M feet, what is the cost per M feet Scribner scale? 72¢ x 0.7353 = 53¢ or the cost per M feet International scale. Then 53 ÷ 0.9044 = 59, or the cost in cents per M feet Scribner scale.

Table 1 may also be used in the following ways for approximately correct results:

1. All the uses described above of table 1 are based on 16-foot logs, but the table may also be used in the same ways even if the logs are longer or shorter than this, without an error (generally) of more than 6 percent.

2. Although the data in table 1 are based on a study of shortleaf and loblolly pine in Southeast Arkansas, this table is applicable to any species of southern pine with a similar taper. Logs having a taper different from that on which the study was based, however, would not have the same cubic-foot volumes and ratios, although in most such cases the error involved would probably not be serious.

3. Table 1 has been prepared for use with individual 16-foot logs of known diameter, but it can also be used for converting volumes or values from one scale to another when the average dimensions of a large number of logs are known. If the logs had little variation in length and diameter, the error involved would not be large, but if the diameters of the logs ranged from 6 to 15 or 20 inches, the error in volumes or values could amount to as much as 15 or 20 percent.

Uses of table 2

Table 2 gives the merchantable volume per tree in board feet by three common log scales, the number of cubic feet (of logs) per tree, the number of cubic feet per M board feet for trees of various diameters, and factors for converting cost or other values from one common log scale to another. Although this table applies specifically to shortleaf and loblolly pine in Southeast Arkansas, it can be applied to these two species growing elsewhere or to other pines in this and other regions having similar taper, log lengths and upper limits of utilization.

This table has the same use for converting costs or values of trees that table 1 has for converting costs or values of logs. The discussion of possible uses of table 1 given above will apply directly to this table, therefore, if the word "tree" is substituted for the word "log".

Table 1

Converting Factors for 16-foot Shortleaf and Loblolly Pine Logs in Southeast Arkansas

Diameter (inside bark) small end of log	Board feet per log (International scale)	Equivalent in			To convert values per M bd. ft. based on International scale to values based on Doyle scale, Scribner scale, or cubic feet, divide by the following figures 2/			Number of cubic feet peeled volume per M board feet when scaled by		
		Doyle scale 1/ (board feet)	Scribner scale 1/ (board feet)	Cubic feet (inside bark)	Doyle scale	Scribner scale	Cubic feet	International scale	Doyle scale	Scribner scale
Inches					- - - - - - - - - - - - - Ratios - - - - - - - - - - - - -					
6.0	19	4	12	4.0	0.2105	0.6316	0.2105	210.5	1000.0	333.3
6.5	23	6	16	4.4	.2609	.6956	.1913	191.3	733.3	275.0
7.0	28	9	21	5.0	.3214	.7500	.1786	178.6	555.6	238.1
7.5	33	12	25	5.6	.3636	.7576	.1697	169.7	466.7	224.0
8.0	39	16	31	6.3	.4102	.7949	.1615	161.5	393.8	203.2
8.5	45	20	36	7.1	.4444	.8000	.1578	157.8	355.0	197.2
9.0	51	25	42	7.9	.4902	.8235	.1549	154.9	316.0	188.1
9.5	58	30	48	8.8	.5172	.8276	.1517	151.7	293.3	183.3
10.0	65	36	55	9.8	.5538	.8462	.1508	150.8	272.2	178.2
10.5	72	42	62	10.8	.5833	.8611	.1500	150.0	257.1	174.2
11.0	80	49	70	11.8	.6125	.8750	.1475	147.5	240.8	168.6
11.5	88	56	78	12.9	.6364	.8864	.1466	146.6	230.4	165.4
12.0	97	64	86	14.2	.6598	.8866	.1464	146.4	221.9	165.1
12.5	106	72	94	15.4	.6792	.8868	.1453	145.3	213.9	163.8
13.0	115	81	104	16.7	.7043	.9043	.1452	145.2	206.2	160.6
13.5	125	90	113	17.9	.7200	.9040	.1432	143.2	198.9	158.4
14.0	136	100	123	19.2	.7353	.9044	.1412	141.2	192.0	156.1
14.5	146	110	133	20.5	.7534	.9110	.1404	140.4	186.4	154.1
15.0	157	121	144	22.0	.7707	.9172	.1401	140.1	181.8	152.8
15.5	169	132	155	23.5	.7811	.9172	.1390	139.0	178.0	151.6
16.0	181	144	166	25.0	.7956	.9171	.1381	138.1	173.6	150.6
16.5	193	156	178	26.7	.8083	.9223	.1383	138.3	171.2	150.0
17.0	205	169	190	28.4	.8244	.9268	.1385	138.5	168.0	149.5
17.5	219	182	203	30.2	.8310	.9269	.1379	137.9	165.9	148.8
18.0	232	196	216	32.0	.8448	.9310	.1379	137.9	163.3	148.1
18.5	246	210	229	33.9	.8536	.9309	.1378	137.8	161.4	148.0
19.0	260	225	243	35.8	.8654	.9346	.1377	137.7	159.1	147.3
19.5	275	240	257	37.8	.8727	.9345	.1374	137.4	157.5	147.1
20.0	290	256	272	39.8	.8828	.9379	.1372	137.2	155.5	146.3
20.5	305	272	287	41.8	.8918	.9410	.1370	137.0	153.7	145.6
21.0	321	289	302	43.8	.9003	.9408	.1364	136.4	151.6	145.0
21.5	337	306	318	45.8	.9080	.9436	.1359	135.9	149.7	144.0
22.0	354	324	334	47.8	.9152	.9435	.1350	135.0	147.5	143.1

1/ Doyle scale is computed from the formula: $V = \frac{(D-4)^2 \times L}{16}$

Scribner scale is computed from the formula: $V = 0.79D^2 - 2D - 4$

International ¼-inch scale is computed from the formula: $V = 0.796D^2 - 1.375D - 1.230$

2/ To convert board feet in the International scale to board feet Doyle scale or Scribner scale, or to cubic feet, multiply by the given values.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.

Table 2

Converting Factors for Shortleaf and Loblolly Pine Trees in Southeast Arkansas

D.B.H. (outside bark)	Merchantable board feet per tree (International scale)	Equivalent in			To convert values per M bd. ft. based on International scale to values based on Doyle scale, Scribner scale, or cubic feet, divide by the following figures[1]			Number of cubic feet per M board feet when scaled by		
		Doyle scale (board feet)	Scribner scale (board feet)	Cubic feet (inside bark)	Doyle scale	Scribner scale	Cubic feet	International scale	Doyle scale	Scribner scale
Inches					- - - - - - - - - - - - - - Ratios - - - - - - - - - - - - - -					
10	53	20	32	13.1	0.3774	0.6038	0.2472	247.2	655.0	409.4
11	79	38	56	14.7	.4810	.7089	.1861	186.1	386.8	262.5
12	107	58	82	17.0	.5421	.7664	.1589	158.9	293.1	207.3
13	137	81	113	20.1	.5912	.8248	.1467	146.7	248.1	177.9
14	168	108	146	24.1	.6429	.8690	.1435	143.5	223.1	165.1
15	202	141	182	29.3	.6980	.9010	.1450	145.0	207.8	161.0
16	239	176	219	34.9	.7364	.9163	.1460	146.0	198.3	159.4
17	280	213	257	41.0	.7607	.9179	.1464	146.4	192.5	159.5
18	325	253	298	47.7	.7785	.9169	.1468	146.8	188.5	160.1
19	375	297	342	55.1	.7920	.9120	.1469	146.9	185.5	161.1
20	431	344	392	62.7	.7981	.9095	.1455	145.5	182.3	159.9
21	492	400	449	70.8	.8130	.9126	.1439	143.9	177.0	157.7
22	561	465	513	79.3	.8289	.9144	.1414	141.4	170.5	154.6
23	631	541	585	88.1	.8574	.9271	.1396	139.6	162.8	150.6
24	706	621	662	97.0	.8796	.9377	.1374	137.4	156.2	146.5
25	785	705	743	105.9	.8981	.9465	.1349	134.9	150.2	142.5
26	867	790	827	114.9	.9112	.9539	.1325	132.5	145.4	138.9
27	950	876	913	124.0	.9221	.9611	.1305	130.5	141.6	135.8
28	1,033	963	1,000	133.0	.9322	.9681	.1288	128.8	138.1	133.0
29	1,116	1,050	1,090	142.0	.9409	.9767	.1272	127.2	135.2	130.3
30	1,200	1,140	1,182	151.0	.9500	.9850	.1259	125.8	132.5	127.7

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[1] To convert board feet in the International scale to board feet Doyle scale or Scribner scale, or to cubic feet, multiply by the given values.

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OCCASIONAL PAPER No. 68 September 15, 1937

SOUTHERN FOREST EXPERIMENT STATION
E. L. Demmon, Director
New Orleans, La.

FACTORS FOR CONVERTING LOG AND TREE VOLUMES OR VALUES FROM ONE COMMON SCALE TO ANOTHER

by

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Uses of table 1

1. If the diameter inside bark of a 16-foot log is given, one can read off directly the volume of the log in board feet by the Doyle, Scribner, or International scales, and also the volume in cubic feet.

2. If the log-scale volume of a 16-foot log is given in any one of the three scales or in cubic feet, one can read off directly the equivalent volume in the other measurement systems.

3. If the log volume of a 16-foot log is given, one can read off directly the diameter inside bark at the small end of the log.

4. If the cost is given of felling and bucking, or skidding and loading, etc., per M feet in the International scale, one can determine the cost per M feet in a different scale. Example: If the cost of felling and bucking per M feet International scale for logs with a top diameter of 12-inches inside bark or 97 board feet is 60¢, what is the corresponding cost for logs of the same size in Doyle scale? From table 1 the converting factor from International scale to Doyle scale for logs of this size is seen to be 0.6598. Then the cost of the felling and bucking in Doyle scale is equal to 60¢ ÷ 0.6598 or 91¢ per M feet.

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[1] From a study of selective logging in southeastern Arkansas.

5. If the cost is given of felling and bucking, etc., per M feet based on a scale other than International, one can determine the cost in the International scale by multiplying this cost by the proper converting factor, as given in the table. Example: If the cost of felling and bucking by Doyle scale is 91¢ per M feet for logs averaging 64 board feet per log, what is the corresponding cost in International scale? From table 1 it is seen that logs of this size have a converting factor of 0.6598. Then the cost of felling and bucking in International scale is 91¢ x 0.6598 or 60¢ per M feet.

6. If the cost is given of felling and bucking, etc., per M feet for logs of a given size based on either Doyle or Scribner, one can determine the cost in the other scale (Scribner or Doyle, respectively) by multiplying the value by the proper converting factor to obtain the value in the International scale, and then dividing by the converting factor for the size and log scale desired. Example: The cost of skidding and loading pine logs containing 100 feet log scale (Doyle) is 72¢ per M feet, what is the cost per M feet Scribner scale? 72¢ x 0.7353 = 53¢ or the cost per M feet International scale. Then 53 ÷ 0.9044 = 59, or the cost in cents per M feet Scribner scale.

Table 1 may also be used in the following ways for approximately correct results:

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Uses of table 2

Table 2 gives the merchantable volume per tree in board feet by three common log scales, the number of cubic feet (of logs) per tree, the number of cubic feet per M board feet for trees of various diameters, and factors for converting cost or other values from one common log scale to another. Although this table applies specifically to shortleaf and loblolly pine in Southeast Arkansas, it can be applied to these two species growing elsewhere or to other pines in this and other regions having similar taper, log lengths and upper limits of utilization.

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8.5	45	20	36	7.1	.4444	.8000	.1578	157.8	355.0	197.2
9.0	51	25	42	7.9	.4902	.8235	.1549	154.9	316.0	188.1
9.5	58	30	48	8.8	.5172	.8276	.1517	151.7	293.3	183.3
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11.0	80	49	70	11.8	.6125	.8750	.1475	147.5	240.8	168.6
11.5	88	56	78	12.9	.6364	.8864	.1466	146.6	230.4	165.4
12.0	97	64	86	14.2	.6598	.8866	.1464	146.4	221.9	165.1
12.5	106	72	94	15.4	.6792	.8868	.1453	145.3	213.9	163.8
13.0	115	81	104	16.7	.7043	.9043	.1452	145.2	206.2	160.6
13.5	125	90	113	17.9	.7200	.9040	.1432	143.2	198.9	158.4
14.0	136	100	123	19.2	.7353	.9044	.1412	141.2	192.0	156.1
14.5	146	110	133	20.5	.7534	.9110	.1404	140.4	186.4	154.1
15.0	157	121	144	22.0	.7707	.9172	.1401	140.1	181.8	152.8
15.5	169	132	155	23.5	.7811	.9172	.1390	139.0	178.0	151.6
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16.5	193	156	178	26.7	.8083	.9223	.1383	138.3	171.2	150.0
17.0	205	169	190	28.4	.8244	.9268	.1385	138.5	168.0	149.5
17.5	219	182	203	30.2	.8310	.9269	.1379	137.9	165.9	148.8
18.0	232	196	216	32.0	.8448	.9310	.1379	137.9	163.3	148.1
18.5	246	210	229	33.9	.8536	.9309	.1378	137.8	161.4	148.0
19.0	260	225	243	35.8	.8654	.9346	.1377	137.7	159.1	147.3
19.5	275	240	257	37.8	.8727	.9345	.1374	137.4	157.5	147.1
20.0	290	256	272	39.8	.8828	.9379	.1372	137.2	155.5	146.3
20.5	305	272	287	41.8	.8918	.9410	.1370	137.0	153.7	145.6
21.0	321	289	302	43.8	.9003	.9408	.1364	136.4	151.6	145.0
21.5	337	306	318	45.8	.9080	.9436	.1359	135.9	149.7	144.0
22.0	354	324	334	47.8	.9152	.9435	.1350	135.0	147.5	143.1

1/ Doyle scale is computed from the formula: $V = \frac{(D-4)^2 \times L}{16}$

Scribner scale is computed from the formula: $V = 0.79D^2 - 2D - 4$

International $\frac{1}{4}$-inch scale is computed from the formula: $V = 0.796D^2 - 1.375D - 1.230$

2/ To convert board feet in the International scale to board feet Doyle scale or Scribner scale, or to cubic feet, multiply by the given values.

Table 2

Converting Factors for Shortleaf and Loblolly Pine Trees in Southeast Arkansas

D.B.H. (outside bark)	Merchantable board feet per tree (International scale)	Equivalent in			To convert values per M bd. ft. based on International scale to values based on Doyle scale, Scribner scale, or cubic feet, divide by the following figures 1/			Number of cubic feet per M board feet when scaled by		
		Doyle scale (board feet)	Scribner scale (board feet)	Cubic feet (inside bark)	Doyle scale	Scribner scale	Cubic feet	International scale	Doyle scale	Scribner scale
Inches					- - - - - -	- - - - - -	- - Ratios - -	- - - - - -	- - - - - -	- - - - - -
10	53	20	32	13.1	0.3774	0.6038	0.2472	247.2	655.0	409.4
11	79	38	56	14.7	.4810	.7089	.1861	186.1	386.8	262.5
12	107	58	82	17.0	.5421	.7664	.1589	158.9	293.1	207.3
13	137	81	113	20.1	.5912	.8248	.1467	146.7	248.1	177.9
14	168	108	146	24.1	.6429	.8690	.1435	143.5	223.1	165.1
15	202	141	182	29.3	.6980	.9010	.1450	145.0	207.8	161.0
16	239	176	219	34.9	.7364	.9163	.1460	146.0	198.3	159.4
17	280	213	257	41.0	.7607	.9179	.1464	146.4	192.5	159.5
18	325	253	298	47.7	.7785	.9169	.1468	146.8	188.5	160.1
19	375	297	342	55.1	.7920	.9120	.1469	146.9	185.5	161.1
20	431	344	392	62.7	.7981	.9095	.1455	145.5	182.3	159.9
21	492	400	449	70.8	.8130	.9126	.1439	143.9	177.0	157.7
22	561	465	513	79.3	.8289	.9144	.1414	141.4	170.5	154.6
23	631	541	585	88.1	.8574	.9271	.1396	139.6	162.8	150.6
24	706	621	662	97.0	.8796	.9377	.1374	137.4	156.2	146.5
25	785	705	743	105.9	.8981	.9465	.1349	134.9	150.2	142.5
26	867	790	827	114.9	.9112	.9539	.1325	132.5	145.4	138.9
27	950	876	913	124.0	.9221	.9611	.1305	130.5	141.6	135.8
28	1,033	963	1,000	133.0	.9322	.9681	.1288	128.8	138.1	133.0
29	1,116	1,050	1,090	142.0	.9409	.9767	.1272	127.2	135.2	130.3
30	1,200	1,140	1,182	151.0	.9500	.9850	.1259	125.8	132.5	127.7

1/ To convert board feet in the International scale to board feet Doyle scale or Scribner scale, or to cubic feet, multiply by the given values.

OCCASIONAL PAPER NO. 69 OCTOBER 11, 1937

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A METHOD OF STUDYING THE FACTORS AFFECTING INITIAL SURVIVAL IN FOREST PLANTATIONS

by

Philip C. Wakeley, Silviculturist,

and

R. A. Chapman, Assistant Silviculturist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

A METHOD OF STUDYING THE FACTORS AFFECTING INITIAL SURVIVAL IN FOREST PLANTATIONS

by

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and R. A. Chapman, Assistant Silviculturist,
Southern Forest Experiment Station.

At one time or another almost every man in charge of a planting operation faces the necessity of studying the effect of various factors upon initial survival [1] of the planted trees. Such studies are particularly likely to be needed when changes in nursery practice, planting tools, or available labor cause a change in the general method of planting; when a new species is added to the list of those planted; when planting is extended to a new territory; or when a review of accounts shows an unduly high cost per thousand trees established. Often, however, the demand for such studies arises at the height of the planting season, when the men in charge have scant time to devise experiments. In addition, the men may have had relatively little experience in investigative planting. As a result, the numbers of trees used in the studies may be either too small for reliability or too large for efficiency, or flaws in arrangement of the plots may cause variations in soil to make insignificant factors appear important or significant ones appear negligible.

This paper describes a method of laying out plantations and of recording survival counts which the Southern Station has found particularly well adapted to the study of most of the factors affecting survival. The method, which requires that the plantations be laid out in what are known as "balanced, randomized blocks", is based on one developed largely by R. A. Fisher. Although at first glance it appears considerably more complex than the old-fashioned "plot and check-plot" studies, or than plantations of two treatments in alternate rows, it is actually very easy to apply if the directions given here are followed step by step. The little extra trouble involved is more than offset by the greater economy of planting and increased dependability of results. These advantages are attained by the internal arrangement of the experimental plantations, which largely eliminates the disturbing effects of irregular moisture supply, variations in soil, and differences in competing vegetation, and which makes it possible, by planting a relatively small number of trees, to measure accurately the net effect of the different treatments being studied.

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[1] Initial survival may be defined as that shown by the planted stock after the occurrence of the mortality more or less directly brought about by the whole process of planting, including the environment chosen for the planted trees. It is usually best measured at the end of the first growing season, but in special cases supplementary measurements may be desirable about the first week in June of the first growing season and at the end of the second or third growing seasons. A study of initial survival should not include effect of epidemics, insect infestations, or droughts after the planted trees are well established, and of course never includes later losses arising from competition as the crowns close.

Many modifications of the method are possible, but unless the planter is an experienced statistician, it is suggested that he follow strictly the application described here, lest he weaken his results or make them entirely unreliable.

Material and Equipment Required

In addition to the necessary planting tools and planting stock, the following materials and equipment will be required to carry out the study; much time and annoyance (and possibly serious errors in the work) can be avoided by preparing them in advance.

1. Office equipment:

   a. A set of wooden "lotto" or "bingo" numbers running from 1 to 60 or higher, for randomizing. They can be obtained at almost any 5- and 10-cent store. Other numbered objects, such as slips of paper or flat metal tags, can not be mixed thoroughly in a reasonable time and should not be used.

   b. A tin can with straight sides, or a cylindrical oatmeal box, for shaking up the numbers.

   c. One establishment report diagram (form 1) for each block. This form is more convenient if typewritten.

   d. One establishment report summary (form 2) for every four blocks. This also should be typed if possible.

   e. One field examination record (form 3) for each examination of each treatment; as a relatively large supply of these forms is involved, mimeographing them is recommended rather than typewriting.

2. Field equipment:

   f. Large, durable corner posts sufficient to mark "block" corners.

   g. Enough small, durable stakes--2 feet is a good length--to mark each end of every row.

   h. At least one measuring cord, 26 times as long as the distance between one tree and the next in the plantation. From two to eight cords will be needed in large studies. Each cord must have a loop at each end to be slipped over the stake at each end of the row, and must be marked at equal intervals, with paint or tags, to show where 25 trees are to be planted in the row, at the spacing chosen. (A spacing of 5 feet between trees and between rows is suggested, as it reduces the size of the plot and makes it easier to find trees on re-examination, but 6 x 6 feet or any other moderately close spacing will serve.)

Size and Arrangement of the Plantation

At any given spacing, the area required for an experimental plantation depends upon the number of treatments to be tested. The method described here is flexible enough to permit from 10 to 60 different treatments in one experiment. It is best adapted, however, to testing 16 to 30 treatments at once. Actual practice has shown that studies of less than 10 or more than 60 treatments made as described in this paper are generally inefficient and lack desirable precision.

The plantation layout has been developed to test each treatment by means of 100 trees. The total number of trees in a study, therefore, equals 100 times the number of treatments. These trees are planted in four blocks of identical size and shape, laid out as follows:

The length of each block is 26 times the distance between two consecutive trees in the row, that is, long enough to accommodate rows of 25 trees each. The width of each block is obtained by adding 1 to the number of treatments to be tested, and multiplying this sum by the distance between two adjacent rows, which should be the same as that between two trees in a row. For 20 treatments spaced 5 x 5 feet, there would consequently be required 4 blocks each 130 x 105 feet.

These four blocks should be laid out on as uniform a site as possible. Furthermore, it is especially important that conditions within each block be uniform; if the site as a whole shows differences that cannot be avoided, the blocks should be laid out so that there is less difference between two parts of any one block than between two blocks each taken as a whole.

On a fairly uniform site the blocks should be laid out end to end in a rectangle; this arrangement has the advantages of simplifying work and saving stakes. On a site marred by small drainage ways, areas of strikingly different soil, or patches of heavy brush, these advantages should be sacrificed and the blocks separated to exclude the disturbing factors; this precaution is necessary to maintain the comparability of rows within each block. The greatest gap between blocks ordinarily should not exceed 100 feet.

When the corners of the four blocks have been established, the next step is to drive stakes at the ends of the blocks, at the spacing decided upon, to mark the beginning and end of each row. The blocks should then be given the designations A, B, C, and D (or other convenient designations), beginning with the block farthest from the road or other avenue of approach. Each series of stakes marking the ends of the rows should be numbered from 1 to 20 (or whatever the number of tests is), with the numbers running from left to right. (Paint, metal tags, or a good, permanent grade of lumber keel may be used to mark the row stakes.)

This system of lettering and numbering is suggested because, as one approaches the plantation from the road gate, it makes an orderly arrangement of block letters, row numbers, and tree numbers, running in the same direction as the writing on a sheet of paper (fig. 1). As will be seen in the sections on planting and on re-examination, ease in finding any particular row is essential to efficient use of the method.

Arrangement of Tests Within Blocks

The blocks can be laid out in the field, staked, and numbered as soon as it has been decided how many methods are to be tested and what spacing is to be used. Before the actual planting can be done, however, the arrangement of tests within blocks must be determined. As the method of experimental planting under discussion depends for its success entirely upon this arrangement, the following directions must be followed exactly:

1. List the treatments to be tested, for example, 20, in any convenient order on form 2, and number them from 1 to 20, as in the example on page 15.

2. Take lotto numbers 1 to 20 and place them in a cup.

3. Take a copy of form 1 and head it for block A, as in the example on page 13.

4. Shake the lotto numbers thoroughly and blindly draw one from the cup without exercising any choice in any way. Copy this number in the second column on form 1, opposite row number 1. Lay the drawn number aside; do not return it to the cup.

5. Draw the rest of the numbers and copy them in the second column of form 1, opposite row numbers 2, 3, 4, etc., laying each aside as soon as copied. This process gives the order in which the various treatments (20 rows of 25 trees each) will be arranged in block A, and in block A only.

6. Head a second form 1 for block B, replace the lotto numbers in the can, shake thoroughly, draw the numbers at random as before, and copy, as drawn, in the second column, to give the order of treatments in block B.

7. Repeat the process for block C; also for block D.

8. Now turn again to form 2, which gives the nature of the treatment corresponding to each treatment number. Using this as a guide, enter the nature of the corresponding treatment opposite each treatment number that has been entered on form 1 for block A, for block B, etc. Form 1 for each block thus becomes a diagram, from which the actual method under test in any row can be read at any time; the row number can of course be read instantly from the stake at the beginning or end of the row.

9. While entering on form 1 the nature of treatment read from form 2, enter also on form 2, in the appropriately lettered column, the number of the row in which that treatment is being tested in the block. This makes of form 2 a cross-index to the location of treatments — an index which is invaluable not only in supervising and checking the work of planting but also in making out the forms for later survival counts.

A word of caution is necessary concerning the process of selecting at random the rows to which the various treatment numbers are assigned. Each block in each experiment must be randomized afresh. Except in the rare event that an identical arrangement appears by chance, the same arrangement must not be used twice, either in the same study or in different studies. If it does appear by chance, it must be used, because the numbers must be accepted as they fall. The person arranging the layout may no more reject a series of drawn numbers "because he doesn't like the looks of it" or because it resembles or duplicates a previous series, than he may substitute a systematic arrangement of tests for the random arrangement upon which the ultimate success of the method depends. If lotto numbers of uniform size are used, and if they are well shaken in a cup that is large enough to permit free movement, the experimenter may feel confidence in such randomizations, which are absolutely essential to the measurement of the precision of results obtained in the study.

Establishment of the Plantation

The following precautions must be observed in the actual establishment of the plantation, lest disturbing factors enter in and obscure the effects of the treatments to be tested.

1. Except in a test of season-of-planting, or of weather-at-time-of-planting, all four blocks should be planted in one day. If they are not, some of the stock will be subjected to one set of weather conditions (risk of drying out, etc.) and some to another. In fact, a week of bad weather intervening between two planting days may seriously derange the experiment. In the example cited on forms 1 and 2, involving method and duration of storage, the stock should be lifted at 5-day intervals and planted all in one day, instead of being lifted all in one day and held for progressively longer periods.

2. It is best if one man (or one pair of men working together) plants all four blocks. If the number of treatments to be tested makes this impossible within the limit of one day, two men (or two pairs) should each plant two blocks, or four men (or pairs) should each plant one block. Two men should never divide the work on any one block.

With the treatments given on forms 1 and 2, for example, one man should not plant all the heeled-in stock and another all the baled stock, because, if the baled stock showed poorer survival, it would be impossible to tell whether losses were the result of baling or of poor planting by one man. Similarly, if one man plants both heeled-in and baled stock on blocks A and B, and a poorer planter plants both stocks on blocks C and D, and if blocks C and D show a low average survival for all treatments, it will be impossible to tell whether the losses on blocks C and D were caused by poor planting or by poor soil on those blocks. This, however, is not important, as the study is of treatments, not of planters or plots of ground, and those particular blocks (and probably also the particular planters) will never be used again. The important thing is that stock from each storage method (heel-in and bale) be equally exposed to both good and bad soils and to good and bad planting so that the true differences between the storage methods, if any, will be brought out.

3. Even at the expense of extra walking and loss of time, it is usually better to plant treatments in numerical order, and to complete each on all four blocks before going to the next treatment, than to plant row 1, row 2, etc., of each block consecutively. The example on forms 1 and 2 illustrates this point clearly. If the bale for treatment no. 2 is opened to plant row 7 of block A, and left open during the planting of rows 8-20 in block A, all of

blocks B and C, and several rows in block D, the stock drawn from this bale for the appropriate row in block D may have been very seriously affected by changes in temperature and moisture. Figure 1 shows the logical progress of planting, through the planting of the first 175 of a total of 2,000 trees.

With these precautions in mind, the simplest way to supervise a small experimental planting is to give one man a measuring string (or, preferably, four strings) and the form 1 for all four blocks, while a second man (or pair), equipped with the necessary tools, gets the stock for each treatment in turn, under the direction of the man in charge. It is advisable to count the stock into four groups of 25 trees each before distributing to the planter, labeling each group with block, row number, and treatment number, read from form 2 by the man in charge.

The man with the marking string glances down the second column of form 1 for block A, sees that treatment 1 is to be planted on row 2, and accordingly stretches a measuring string from the no. 2 stake on the far side of block A to the no. 2 stake on the near side. Then the planter, or pair of planters, plants one tree at each mark on the string and tucks the label from the bundle of trees into the grass at the foot of the stake at the far end of the row. Meanwhile the "string-man" goes to block B and stretches a string between the appropriate stakes (marking row 17), shown by the position of treatment no. 1 in the second column of form 1 for block B.

Even on the largest studies, with four blocks of 60 rows each, the same system works. A study of this size, however, requires four planters (or pairs); each block then requires one planter, a string-man, two strings, and, if possible, a carrier to relieve the planters from walking back and forth with supplies of stock. Under this arrangement, the string-men carry the copies of form 1 for their respective blocks.

The Southern Forest Experiment Station, working on blocks laid out as described with a crew of 13 experienced CCC enrollees (4 string-men, 4 planters, 4 carriers, and 1 tree-counter to assist the officer in charge) and using 8 strings, has planted 7,200 trees in 5 working hours, without undue haste The stakes, of course, had all been driven and numbered in advance.

Each string-man, as he finishes stretching a string, should check off both row number and treatment number, in pencil, on form 1. When the planting has been completed, the man in charge of the work should go along each row of stakes, picking up the labels removed from the groups of trees and checking the stake number and label against form 2. If any error has occurred, forms 1 and 2 should be corrected to show the actual location of the treatments on the ground, as these forms are an essential part of the record and constitute the guide to re-examination.

Forms 1 and 2, completely filled in, together with a map showing the location of all the blocks, and with descriptions of the stock (including seed source), planting site, weather during planting, and treatments being tested, constitute all the establishment report needed.

Type of Survival Study to Which the Foregoing Layout is Particularly Adapted

The layout just described is especially adapted to the study of factors affecting the individual tree rather than the entire planting site. Such factors are the species, age, class, grade, health, or size of the planting stock; its treatment by cultivation, fertilizing, shading, or watering in the nursery; root pruning during the growing season or at lifting time; mechanical injury or exposure during lifting or planting; method or duration of storage of planting stock; season of planting; depth of planting; tool used; localized site preparation, such as plowing of furrows or hoeing of spots; control of pests by various sprays; and control of drought injury by shading, mulching, coating with oil, or pruning the needles. Most survival studies involve just such factors.

The layout of four balanced blocks, each with treatments randomized by 25-tree rows, is not adapted to studies of the effect of treatments applied to the site as a whole rather than to the individual tree. Such studies include eradication or control of animals, insects, or diseases by scattered baits, poison applied to burrows, or removal of alternate hosts; control of competing brush large enough to exert its influence beyond the width of a row; preparation of the entire site, as by burning or by complete plowing and harrowing; and effect of soil type or topography. It is obviously impossible to get typical burns on single rows, or to arrange ridges, slopes, and draws according to the chance order of the lotto numbers. For studies of this kind special techniques must be developed.

In choosing the treatments to include in one study, that is, in one set of four blocks, care must be taken to compare similar things. Except as noted in the following section, any one study should be confined to variations of one factor (such as root length, storage, or planting tool), or should test several complete planting systems such as have been developed and found effective in different territories. A study should not include comparisons between "date of planting" and "2-year-old stock", or between "seedlings fertilized in nursery" and "seedlings heeled-in for 40 days"; such miscellaneous comparisons are meaningless.

Special Cases

A modification of the general method very greatly increases the effectiveness of the layout in many instances, especially if the number of available treatments (for example, tools, or root lengths) falls below 15. This modification involves applying each of several original treatments (perhaps 10, as in the case of tools) to each of two species, or to each of two ages or grades of planting stock. The combination of several original treatments with two species is especially effective; in fact, three or even four species may sometimes be used to advantage.

In applying this modification, each combination of original treatment (such as tool) with species constitutes a separate final treatment. For example, 10 tools tried simultaneously with longleaf and slash pine would give a total of 20 treatments to randomize over each block, with each tool represented by 50 trees (25 longleaf and 25 slash) on each block, and each species by 250 trees (25 for each tool) on each block.

There are two advantages of this special modification: One is that it makes it possible to test a limited number of original treatments (such as 10 tools) and still bring the number of rows in each block within the range (16 to 30) which appears most effective; the other is that it brings to light any differential response of species (or age or grade of stock) to treatment. One tool, for example, may work well with longleaf and poorly with slash pine, or the shortest permissible root length for one species may differ by 2 or 3 inches from that for the other. Such information is extremely valuable in determining planting policies and in supervising routine commercial planting of either species.

Re-examination of the Plantation to Record Survival

Re-examination of the plantation, apparently complicated by the random arrangement of treatments in each block, is actually very simple, provided only that the numbers on the stakes marking the rows are distinct and that form 2 is correctly made out. The ease of examination results from the use of form 3,[2] one copy of which is needed for each treatment being tested.

To prepare the forms for re-examination, enter at the head of the first copy of form 3 the study, species, and nature of treatment for treatment no. 1, taken from form 2 as made out when the plantation was established (see pages 4 and 15). At the tops of the four main columns on form 3 enter the block designations, A, B, C, and D, as shown. Then, from form 2 take the number of the row in which treatment no. 1 was planted in each block, and enter it under the designation of that block on form 3. In like manner prepare forms for treatments 2, 3, etc. (see page 17).

For most efficient field work in re-examination, go first to row 1 in block A. Take the sheets (form 3) for all 20 treatments (or whatever the number is) and arrange them in numerical order according to the row numbers entered in the first main column, under the heading "Block A." Go down row 1, entering the condition, etc., of each tree opposite the tree number on form 3. Tree 1 in row 1 should be in the far, left-hand corner of the block as it is approached from the road or gate, as suggested on page 3 and in figure 1. A measuring stick may help to speed up the work if survival is low or if the trees are hard to find in the grass; in extreme cases it may save time to stretch the original measuring string along the row. Since exactly 25 trees were planted in the row, the list of trees living, dead, or missing must total 25 in the corresponding column on form 3.

When the main column for row 1 of block A has been filled in, replace the form 3 for that row with the one for row 2, move over one space in the plantation to row 2, and enter the record for that row on its form. It is not necessary to walk back to the no. 1 tree in row 2; the row can be run in reverse by starting at the bottom of the main column on form 3, opposite tree no. 25, and working upward on the form.

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[2] Form 3, originated by C. F. Olsen, Assistant Silviculturist, Southern Forest Experiment Station, is essentially a mechanical means of "unrandomizing" the randomized rows for purposes of re-examination and averaging. The reduction in cost and in errors resulting from its use in an important factor in making the method of randomized balanced blocks feasible for extensive studies of survival in forest planting.

When the last (for example, the 20th) row in block A has been examined, in each of the 20 forms the first, or left-hand, main column will be filled in, and the other three main columns will be blank. The next step is to arrange the 20 forms in numerical order, based on the row numbers in the second main column, for block B. When this has been done, proceed with the examination of block B as with block A, and repeat for blocks C and D.

For the sake of uniformity in accuracy and judgment, it is best to have one man re-examine all the trees in one study. In the case of very large studies, or of great numbers of studies, it may be necessary to work with several assistants. If four assistants are used, one might be given the first five rows on each block, the second the next five, and so on. By giving the same man the same portion of each successive block, slight differences in accuracy and judgment are "averaged out" by the random arrangement of treatments, just as are slight differences in soil within each block. Gross differences in accuracy and judgment, however, can not be tolerated.

Form 3, as given, provides for records of vigor and injury, as well as of survival. Such records, if carefully taken, may add greatly to the value of the study, and their inclusion tends to increase the accuracy of the survival counts. At the bottom of form 3 are shown symbols (capital letters for condition and vigor, small letters for injuries) found useful by the Southern Forest Experiment Station; other symbols may be added as needed. It must be remembered, however, that the plantation has been established primarily to study survival. All other information is of secondary importance, and form 3 may therefore be simplified by omitting all "vigor" and "injury" columns and retaining merely a "condition" column for each block.

Analysis and Summary of Results

Since each treatment has been tested by planting 100 trees (25 per treatment per block), the total number of living trees recorded on form 3 for that treatment constitutes the survival percentage.

The survival percentages for the various treatments may be entered along the right-hand margin of form 2, or summarized or tabulated in any other manner desired. The ideal procedure is to make an analysis of variance and to test the significance of the differences between the survival percentages of different treatments,[3] but this requires both extra time and considerable familiarity with statistical technique.

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[3] This method of analysis was first used by Fisher and is presented in: Fisher, R. A. Statistical methods for research workers. Ed. 5, rev. and enl. 319 pp., illus. London. 1934.

For an elementary description of the analyses, see:

Bruce, Donald, and Schumacher, Francis X. Forest mensuration. 360 pp., illus. [Part II.] New York and London. 1935.

Snedecor, George W. Calculation and interpretation of analysis of variance and covariance. 96 pp., 35 tables. Monograph No. 1. Division of Industrial Science, Iowa State College. Collegiate Press, Inc., Ames, Iowa. 1934.

Tippett, L. H. C. The methods of statistics. 222 pp., illus. [Chs. VI and X.] London. 1931.

It should be emphasized, however, that these elaborate statistical analyses merely measure and describe the precision and reliability of the results, and are useful only because they show what the odds are that the observed differences in survival are the result of the treatments and not of chance. The precision and reliability have already been attained by the randomization of treatments within balanced blocks, and are there whether measured and described or not. In other words, the man establishing an experimental plantation may be assured that differences in survival shown by several treatments tested according to the methods here described reveal the relative value of the treatments much more clearly than they would if each treatment had been confined to one 100-tree row running across the entire planting site.

The principle involved can be illustrated very simply. Suppose 20 treatments are being tested, by means of 100 trees each, planted in a rectangular block in which there is an evident decrease in soil quality from north to south. The careful experimenter presumably would have his rows run north and south, so that some of the trees in each row would fall on good soil and some on poor. Suppose, however, that for the width of one or two rows along the west edge of the plot there is a strip of soil that appears to the eye to be like the rest, but is actually much more favorable to initial survival. If each treatment is confined to a single row running the length of the plot, the one or two rows falling on the strip of good soil will show an initial survival out of all proportion to the merits of the treatments tested in those rows. But if the plot is divided into four equal blocks, each 25 trees long, and the treatments are rearranged at random in each block, the odds are very small that any one treatment will fall on the strip of good soil in all four blocks. If it falls elsewhere, even in only one block, the average survival of that treatment is decreased, and the average survival of the treatment that replaces it on the good soil is increased, thus reducing the differences in average survival arising solely from soil fertility. The principle that applies in the case of such a narrow strip of favorable soil applies equally to soil or other variations of any other size or shape.

Summary of Precautions

To aid in avoiding delay or errors in establishing survival studies, the following precautions are summarized in the order in which the need for them is likely to occur:

1. Have clearly in mind the kind and number of treatments to be tested, being sure that all those in one study may be legitimately compared or contrasted.

2. Record the description of each treatment in writing, so that the successful treatments can be unquestionably duplicated and the unsuccessful ones avoided in later practice.

3. Before beginning actual installation, obtain lotto numbers, a receptacle for shaking, a supply of forms, the required number of marking strings, and the necessary corner posts and row stakes.

4. In laying out the plantation, take every reasonable precaution to have uniform conditions throughout each individual block.

5. If unavoidable differences occur over the planting area as a whole, lay out the blocks so that the greatest differences occur between one block and another, and the least possible differences within any one block.

6. Keep blocks fairly close together, each preferably within 100 feet of the next, if not actually adjoining.

7. Mark the blocks with durable posts, plainly labeled, before planting; the blocks should also be mapped for the office record.

8. Stake the rows before planting.

9. Number the rows systematically, preferably as shown on page 3 and in figure 1.

10. In randomizing treatments over block diagrams (form 1), mix the lotto numbers very thoroughly, and draw, list, and retain the numbers as they come, without bias, laying each number aside as drawn.

11. Check forms 1 and 2 against each other before beginning planting.

12. Plant the entire study in one day (unless it is a study of weather-on-day-of-planting, or of date-of-planting). Do not start work if rain threatens to prevent completion.

13. Use one planter or pair of planters for the entire study, if the study is small enough for them to complete in one day. If it is too large for this and more men must be used, be sure that each block is planted by the same man (or pair) throughout. Within any one block never have one species or treatment planted by one man, and another by another man.

14. Be careful not to introduce any disturbing factors, such as using seedlings of one seed source or date of sowing for one treatment and of a different source or date for another; exposing part of the stock in treatment no. 1 to a much longer period of drying than the rest; or dipping part of the stock in water and planting the rest without dipping. In the example cited on pages 4, 13, and 15, the "fresh checks" for the storage study must also be baled and heeled-in, if only for a minute, lest they benefit from less handling as well as from prompter planting than the other stock.

15. Before leaving the planting site, be absolutely sure that the records on forms 1 and 2 agree with the location of the treatments on the ground.

16. Before beginning re-examinations, check all copies of form 3 for accuracy of species, treatment, and block and row designations.

17. In re-examining any one block, be particularly careful to avoid entering data for two rows on the same sheet of paper. Take a new sheet for each new row of trees.

18. In running from the high-numbered to the low-numbered end of the row, remember to begin at the bottom of the corresponding column on form 3.

19. Allow plenty of time for re-examination and thus avoid careless inaccuracies. Search thoroughly before calling a tree "B" (=missing, or blank). If this work is entrusted to subordinates, be sure that they are adequately trained and instructed, and check their work by examining a number of rows without letting them know which rows you are going to check.

20. Be sure that every form (1, 2, or 3) includes the name or description of the study (including species), the season of establishment, the date the form was filled in, and the name or initials of the man responsible for the accuracy of the data.

SAMPLE FORM 1. ESTABLISHMENT REPORT DIAGRAM

Block A. Study: Test of method and duration of storage of slash pine planting stock

Planted by____________________________ on__________________, 193_.

Supervised by____

Row No.	Treatment No.	Nature of treatment
1	19	Heeled-in, then taken up and planted immediately
2	1	Heel-in 5 days
3	15	Heel-in 40 days
4	17	Heel-in 45 days
5	16	Bale 40 days
6	3	Heel-in 10 days
7	2	Bale 5 days
8	18	Bale 45 days
9	6	Bale 15 days
10	13	Heel-in 35 days
11	10	Bale 25 days
12	9	Heel-in 25 days
13	5	Heel-in 15 days
14	11	Heel-in 30 days
15	12	Bale 30 days
16	8	Bale 20 days
17	4	Bale 10 days
18	7	Heel-in 20 days
19	14	Bale 35 days
20	20	Baled, then unpacked and planted immediately

SAMPLE FORM 2. ESTABLISHMENT REPORT SUMMARY

Study: Test of method and duration of storage of slash pine nursery stock

Established by______________________________ on____________________, 193_.

Treatment No.	Nature of treatment	Row occupied by treatment in block:			
		A	B	C	D
1	Heel-in 5 days	2	17	18	11
2	Bale 5 days	7	4	17	etc.
3	Heel-in 10 days	6	20	etc.	
4	Bale 10 days	17	etc.	etc.	
5	Heel-in 15 days	13	etc.		
6	Bale 15 days	9			
7	Heel-in 20 days	18			
8	Bale 20 days	16			
9	Heel-in 25 days	12			
10	Bale 25 days	11			
11	Heel-in 30 days	14			
12	Bale 30 days	15			
13	Heel-in 35 days	10			
14	Bale 35 days	19			
15	Heel-in 40 days	3			
16	Bale 40 days	5			
17	Heel-in 45 days	4			
18	Bale 45 days	8			
19	Heeled-in, then taken up and planted immediately	1			
20	Baled, then unpacked and planted immediately	20			

SAMPLE FORM 3. FIELD EXAMINATION RECORD

Study: Test of method and duration of storage of slash pine planting stock

Established by________________________ on________________________, 193_.

Re-examined by________________________ on________________________, 193_.

Species: Slash pine Nature of treatment: No. 1 Heel-in 5 days

Tree No.	Block A			Block B			Block C			Block D			Notes
	Row No. 2			Row No. 17			Row No. 18			Row No. 11			
	Condition	Vigor	Injury by	Condition	Vigor	Injury by	Condition	Vigor	Injury by	Condition	Vigor	Injury by	
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
Totals													

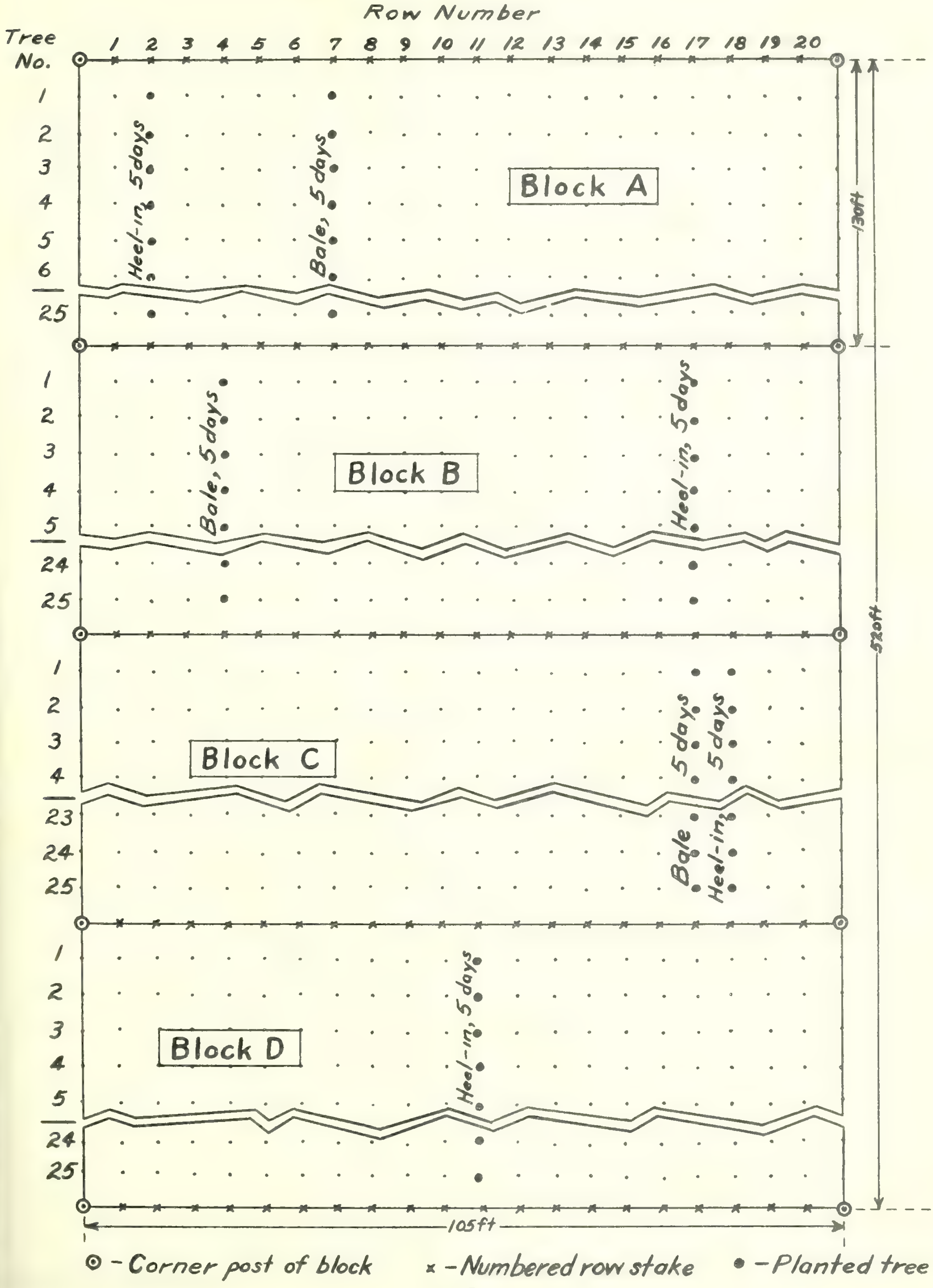
SYMBOLS

Condition
L = living
D = dead
B = blank (missing)

Vigor
T_1 = very thrifty
T_2 = thrifty
G_1 = growing
G_2 = growing poorly
F_1 = failing
F_2 = almost dead

Cause of injury
a = ants
e = erosion
d = drought
f = fungi
g = gophers
i = insects (not ants)
p = poor planting
r = rabbits
s = silting

Figure 1. Diagram of storage study plantation described in text, showing location of first 175 trees planted.



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PROFITABLE MANAGEMENT OF SHORTLEAF AND LOBLOLLY PINE FOR SUSTAINED YIELD

by

W. E. Bond, Senior Forest Economist,

W. G. Wahlenberg, Forester,

and

Burt P. Kirkland, Principal Forest Economist.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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PROFITABLE MANAGEMENT OF SHORTLEAF AND LOBLOLLY PINE FOR SUSTAINED YIELD

By W. E. Bond, Senior Forest Economist,
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and Burt P. Kirkland, Principal Forest Economist.

INTRODUCTION AND GENERAL RECOMMENDATIONS

Maintenance and stabilization of land ownership and of the timber industry with its associated communities in the shortleaf and loblolly pine region depends very largely on keeping forest lands continuously productive. A system of sustained-yield management, which in a practical way correlates the economic requirements of forest owners of this region with those measures necessary to maintain and build up the forest resources, is described in this paper. The conclusions and general recommendations can be stated briefly as follows:

Fire Protection

Protection from fire in the shortleaf-loblolly pine-hardwood type of forest is, in general, not adequate unless it limits the area burned each year to less than 1 percent of the total forest area protected.

Regulation of the Cut

To safeguard future yields of timber the maximum volume cut from a forest property during any period should not exceed the estimated growth of merchantable timber during the period. In forests not up to capacity production, in order to increase future yields the annual cut usually should not remove more than 80 percent of the annual growth. The total volume of timber on a large property and its rate of increment can be determined most economically by a preliminary survey, in which the entire forest is covered systematically, although the sample plots on which the trees are measured need not total more than 1 percent of the entire area. Such a non-intensive cruise does not attempt to map or determine volumes of bodies of timber, but it provides the basis for a determination of the cut. A generalized, flexible, and inexpensive plan of management will suffice for the whole forest until local, first-hand experience in growing timber on specific subdivisions of the property can furnish a basis for more detailed specifications of management. Early subdivision of the property into permanent compartments for management, administration, and utilization purposes is desirable.

Cutting Procedures

The relatively high and constantly increasing accessibility of southern pine forests permits the rapid extension of logging operations over large areas. Cuts should be made at 5- to 10-year intervals in all commercial stands, and not more than 25 to 35 percent of the merchantable growing stock should be removed in any one cut. The less promising trees should be removed from all merchantable size-classes, the selection being made on the basis of their relative financial maturity. No trees should be cut until marked by a reliably trained crew working under the supervision of a competent forester. Proper selection of reserved trees will build up growing stocks and provide for a very desirable shift in the major portion of the future growth and yield from the smaller and inferior trees to the larger and better ones. The marking crew should tally all merchantable sawtimber to be cut and all to be reserved. Such a record serves not only to control the proportion of the current cut, but also will be valuable later in checking net rates of volume growth, by comparison with subsequent records of the same sort.

Profits

The crucial question in the commercial application of any constructive program is: "Will it pay?" In second-growth forests the greatest possibility of profit lies in a combination of selective cutting with a skillful integration of utilization for various forest products. Only in this way can advantage be taken of the wide variation in values between trees suitable for specific purposes. The method of management recommended here is based on these principles, and it is believed that such management will prove more profitable in this type than clear-cutting or other methods now in use.

Stands of about 3,000 board feet per acre, on average sites, generally may be expected to yield an annual profit of $1.00 per acre under existing market conditions, and the prospects are bright that this profit can be increased by good management.

DEFINITION AND NATURE OF SUSTAINED-YIELD MANAGEMENT

Sustained-yield forest management probably has never been better defined, from the practical standpoint, than in Schedule C of the Lumber and Timber Products Code:1/

"Sustained-yield management is defined as management of specific forest lands under single ownership or cooperative control within an economic unit, under a definite management plan which limits timber cutting to the capacity of such forest lands under existing methods of management, as determined from existing growing stock and growth, to provide without interruption or substantial reduction raw material for industry and community support."

This definition, approved after careful consideration by a committee representing public and private forest agencies established in connection with the Lumber and Timber Products Industry Code of 1933, clearly excludes from designation as products of sustained-yield management the low minimum-rate yields from neglected and mismanaged forests, even though these yields may have become stabilized. This exclusion is reasonable because, as will appear later in this paper, such mismanaged and neglected forests cannot produce more than a fraction of their potential yields in volume and quality. The mismanagement in such forests is usually characterized by premature cutting of developing trees and stands; removal of better trees and species, leaving the poorer ones to occupy the ground; failure to cut so as

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1/ Lumber Code Authority Bull. 95. Section 2 (9) of Schedule C, page 4.

to regulate the stand density; neglect of regeneration; and disregard of protection against fire and other sources of damage. Therefore, low yields may be continuously forthcoming without attaining true sustained-yield management.

Although the code definition rightly emphasizes the continuity of yield "for industry and community support," it also infers, though it does not specifically so state, that the yield of forest raw materials of higher quality should be sustained, i.e., not mere volume production is to be sought but quality production as well. For profitable management this is of the first importance, which means that promising trees should be held until they approach real maturity, trees of inferior form should be removed early, stand density should be regulated, and the more desirable species should be favored.

It follows that in starting sustained-yield management of forests not previously managed systematically, yields based on maintenance of the present unsatisfactory conditions are not enough. As rightly emphasized in the code definition, however, initial yields must be calculated on the basis of "existing methods of management, as determined from existing growing stock and growth." In other words, the cut at the beginning should not be so great as to cause further deterioration of the forest. Sound plans of management, however, almost universally make further provisions and provide for building up the forest property to levels where it will provide a sustained yield of greater volume and higher quality.

Aside from protection against fire and other adverse influences, one of the first tasks of forest owners or groups of owners wishing to initiate a sound sustained-yield policy, looking to a progressive betterment of their forestry property, is to fix upon a safe annual cut under existing conditions. Increase of the cut will be warranted as conditions are improved. This forces the forest owner or his authorized representatives to confront the chief problems of sustained-yield management: determination of the present volume and quality of the growing stock, the possibilities of improving it, and measures to insure this improvement.

While sustained-yield management can be applied with various degrees of profit to the majority of forest properties in the shortleaf and loblolly pine region, it must be recognized that there are many properties that do not qualify for this type of management. For example, there are large areas on which the timber has been liquidated, or on which liquidation will be completed within a few years. On these properties the growing stock has been so depleted that, under continuous management, returns will not meet carrying charges for many years. Unfortunately, reclamation of these depleted forest areas must remain for a long time one of the important problems of this region, imposing a burden on other productive land. Sustained-yield management, as described herein, does not contemplate measures which may require a lifetime, such as the restoration of seriously depleted forests or the production of a new growing stock by seeding or planting on bare land. On the contrary, a system of management is recommended which can be applied profitably to such thrifty second-growth stands as now commonly exist in many parts of this forest region. If good forest management is attained for these stands, the forest resources and forest industries in this region will be maintained or even increased, so that a continuous flow of income to labor will result and community interests will continue to be safeguarded.

THE FOREST GROWING STOCK

Sustained-yield forest management aims to obtain the maximum net returns over a long period. The size of the income from a forest property depends primarily upon the amount and value of present yields from existing stands and upon the extent that these yields are increased in volume and value under management. Since the condition of the growing stock and the possibilities of improving it are such important factors in sustained-yield management, they are discussed here in some detail.

Definition

For practical purposes the growing stock may be defined, as a whole or in part, as follows:-

The total growing stock on a given area consists of all trees growing thereon of whatever age and species. It includes seedlings, saplings, and trees of pole- and sawlog-size, whether merchantable or unmerchantable. It is best evaluated by stating the number of trees in each diameter-class as shown by figure 1-A and the subjoined tabulation. It may also be measured in terms of basal area,[2] as shown in figure 1-B. Partial measurement of stem volume can be expressed in cubic measure, as in figure 1-C and the subjoined tabulation.

Of more influence on immediate sustained yield than the total growing stock is that part which may be termed the merchantable growing stock, which consists only of trees in those size-classes which when cut and properly prepared will make some salable raw material. In southern pines very few such products can be made from trees below the 6-inch diameter-class (i.e., trees under 5.0 inches d.b.h.) so that this is ordinarily the smallest diameter-class for which basal area or volume need be computed.

Of still more significance is the sawlog growing stock, which is that portion of the salable species of a size and quality to make merchantable sawlogs. Although sawlogs are frequently made in the South from smaller trees, extensive studies have shown that profitable sawlogs can seldom be made from trees under 13 inches d.b.h. Sawlog growing stock may be measured also in board-foot volume, as shown in figure 1-D.

Timber Classes

In order to consider both the possible merchantable uses of the present growing stock as well as its possible future development under various cutting practices, an extremely useful procedure is to classify the growing stock into timber classes or groups of diameter-classes, as shown in figure 1, in which the following groups are designated:

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[2] The basal area of a stand is the area in square feet of the total cross-sections of all trees in the stand measured at breast height ($4\frac{1}{2}$ feet above the ground).

Timber Class	Diameter at Breast Height	2-Inch Diameter-Classes
Seedlings	Under 1.0 inch	
Saplings	1.0 to 4.9 inches, incl.	2, 4 inch
Poles	5.0 to 12.9 inches, incl.	6, 8, 10, 12 inch
Small sawtimber	13.0 to 20.9 inches, incl.	14, 16, 18, 20 inch
Large sawtimber	21.0 inches and over	22 inch and over

A small portion of the pole stand (5 to 12.9 inches) is sufficiently straight and clear to be valuable for posts and poles, but the major portion of these tree sizes can yield only the low stumpage prices characteristic of pulpwood, fuel, and other cordwood.

In the small-sawtimber class those trees (usually not over 20 percent of the stand) qualified for high-class poles and piling have a high stumpage value, but they are still only moderately valuable for sawtimber, especially if in the smaller diameter-classes. One of the most recent logging- and milling-cost studies in loblolly and shortleaf pines reveals that 13-inch trees provide a margin (for stumpage, profit, and compensation for risks) of only $2.42 per M board feet.

In the larger-sawtimber class, 22-inch trees yield a margin of $9.91 per M board feet and 26-inch trees $12.56, for stumpage, profit, and risks. No data were obtained on larger timber. Obviously, operations in the larger size-classes not only yield much greater stumpage returns (earnings on the investment in land and growing stock) but provide safer margins to cover operating risks and profit. Not only are larger size-classes of the first importance in their effect on immediate revenues, but as will be developed later, they provide the foundation for current growth of high-value material.

Both the distribution of growing stock on the average acre and its distribution over the entire forest property have much bearing on management procedures, although the latter is less important on those properties all parts of which are accessible to logging operations. The quantity of the growing stock and its distribution in diameter-classes are determined by an inventory, as discussed under "Organizing a forest property under sustained-yield management."

Improvement of Growing Stock

In practicing sustained-yield management on a forest property attention should be given not only to current yields, but also to the improvement of the growing stock from which future production of high-quality timber must be obtained. A flexible program of cutting, which responds to changing markets and prices, rather than a rigid plan is desirable. In stands of second-growth shortleaf and loblolly pine of irregular density, composition, age, and quality, non-earning and low-earning timber should be liquidated in the order of its relative financial maturity, and higher-earning timber should be held until it approaches financial maturity. 3/ By this method of selection the productive capacity of the soil is directed toward its

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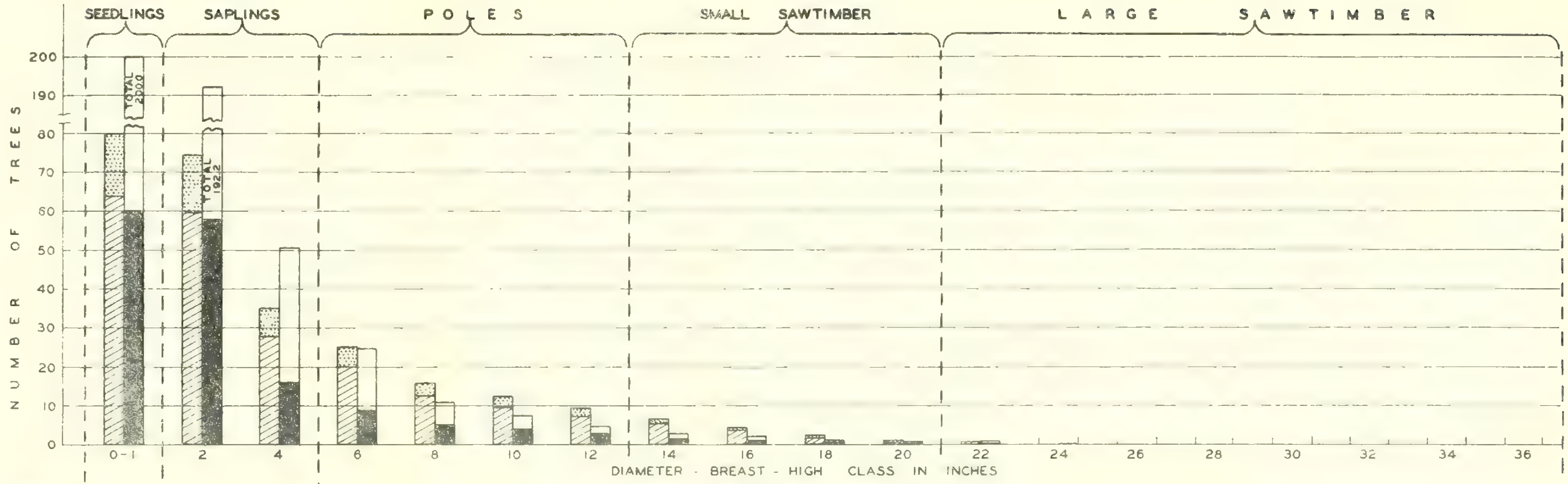
3/ Financial maturity may be defined as the time when the individual tree or stand will no longer make a profitable increase in volume or quality.

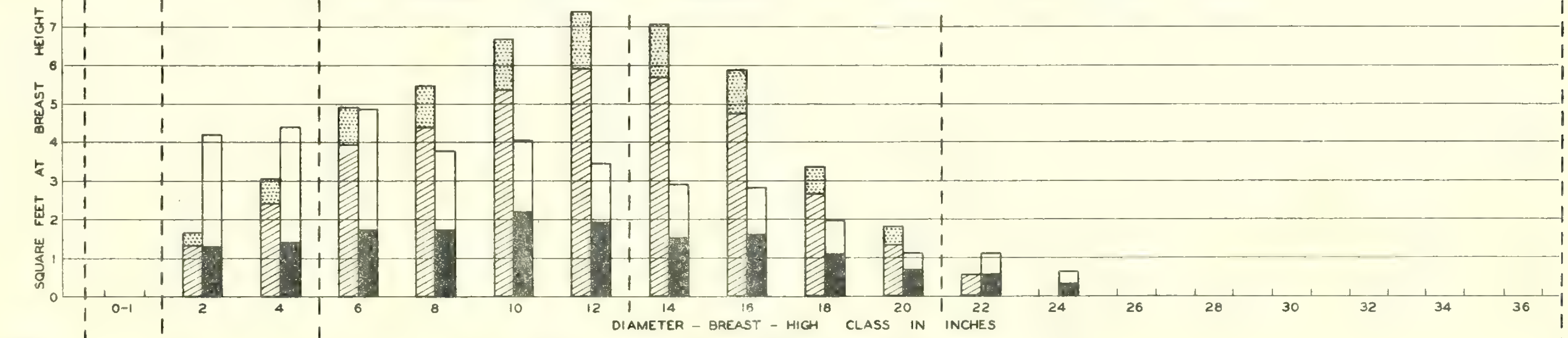
FIG I-A GROWING STOCK EXPRESSED IN NUMBERS OF TREES PER ACRE



NUMBER OF TREES PER ACRE

	0-1	2	4	6	8	10	12	14	16	18	20	22	24	TOTALS
PINE														
DESIRABLE	64.0	59.8	28.1	20.1	12.6	9.8	7.5	5.3	3.4	1.5	0.6	0.2		53.0
UNDESIRABLE	16.0	14.9	7.0	5.0	3.1	2.4	1.9	1.3	0.8	0.4	0.2			212.9
TOTAL	80.0	74.7	35.1	25.1	15.7	12.2	9.4	6.6	4.2	1.9	0.8	0.2		265.9
HARDWOODS														
DESIRABLE	60.0	58.0	16.0	8.7	4.9	4.0	2.4	1.4	1.1	0.6	0.3	0.2	0.1	157.7
UNDESIRABLE	140.0	134.2	34.5	16.0	6.0	3.4	2.0	1.3	0.9	0.5	0.2	0.2	0.1	339.3
TOTAL	200.0	192.2	50.5	24.7	10.9	7.4	4.4	2.7	2.0	1.1	0.5	0.4	0.2	497.0
PINE & HARDWOODS	**280.0**	**266.9**	**85.6**	**49.8**	**26.6**	**19.6**	**13.8**	**9.3**	**6.2**	**3.0**	**1.3**	**0.6**	**0.2**	**762.9**
	280.0	352.5		109.8				19.8				0.8		

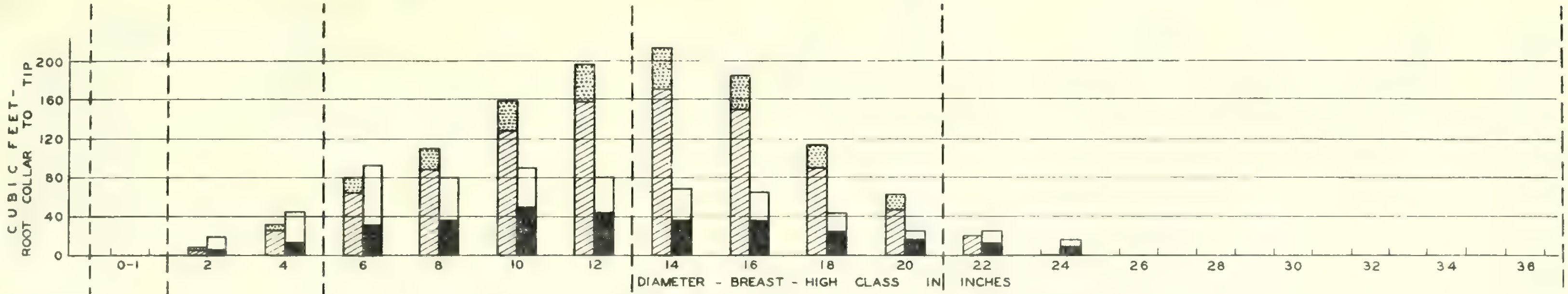
FIG I-B GROWING STOCK EXPRESSED IN BASAL AREA PER ACRE



BASAL AREA IN SQUARE FEET PER ACRE

	0-1	2	4	6	8	10	12	14	16	18	20	22	24	TOTALS
PINE														
DESIRABLE		1.31	2.44	3.94	4.40	5.34	5.89	5.66	4.74	2.65	1.31	53		38.21
UNDESIRABLE		.33	.61	98	1.08	1.31	1.49	1.39	1.12	.71	.44			9.46
TOTAL		1.64	3.05	4.92	5.48	6.65	7.38	7.05	5.86	3.36	1.75	53		47.67
HARDWOODS														
DESIRABLE		1.28	1.39	1.70	1.71	2.18	1.88	1.50	1.54	1.06	.65	.53	.31	19.41
UNDESIRABLE		2.95	3.00	3.14	2.09	1.85	1.57	1.39	1.25	88	.44	.53	32	15.73
TOTAL		4.23	4.39	4.84	3.80	4.03	3.45	2.89	2.79	1.94	1.09	1.06	.63	35.14
PINE & HARDWOODS		**5.87**	**7.44**	**9.76**	**9.28**	**10.68**	**10.83**	**9.94**	**8.65**	**5.30**	**2.84**	**1.59**	**.63**	**82.81**
		13.31		40.55				26.73				2.22		

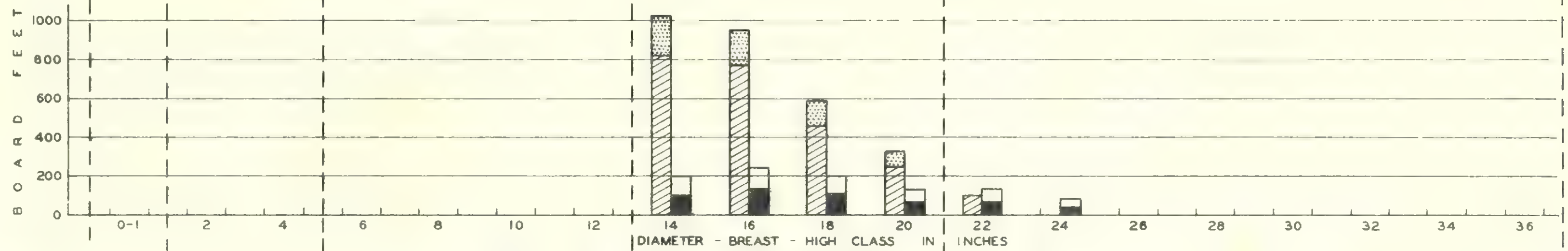
FIG. I-C GROWING STOCK EXPRESSED IN CUBIC FEET PER ACRE



TOTAL VOLUME OF STEMS (ROOT COLLAR TO TIP) IN CUBIC FEET

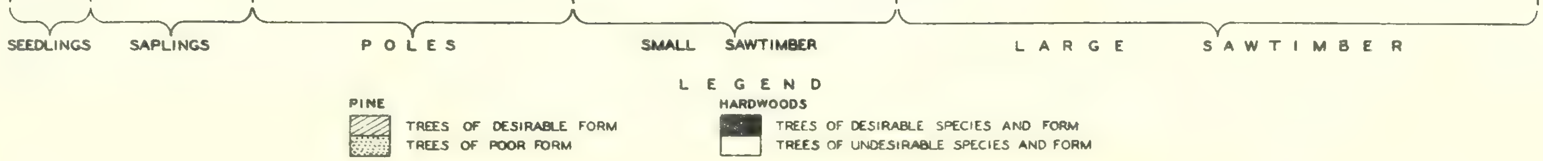
	0-1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	TOTALS
PINE																				
DESIRABLE		6.0	25.3	64.3	88.2	127.4	157.5	169.6	149.6	90.0	46.2	19.6								943.7
UNDESIRABLE		1.5	6.3	16.0	21.7	31.2	39.9	41.6	35.2	24.0	15.4									232.8
TOTAL		7.5	31.6	80.3	109.9	158.6	197.4	211.2	184.8	114.0	61.6	19.6								1176.5
HARDWOODS																				
DESIRABLE		5.8	14.4	32.2	35.8	48.8	43.9	35.1	35.4	24.3	15.1	12.4	7.6							310.8
UNDESIRABLE		13.4	31.0	59.2	43.8	41.5	36.6	32.6	29.0	20.3	10.0	12.3	7.6							337.3
TOTAL		19.2	45.4	91.4	79.6	90.3	80.5	67.7	64.4	44.6	25.1	24.7	15.2							648.1
PINE & HARDWOODS		26.7	77.0	171.7	189.5	248.9	277.9	278.9	249.2	158.6	86.7	44.3	15.2							1824.8
		103.7		888.0				773.4				59.5								

FIG. I-D SAWLOG GROWING STOCK EXPRESSED IN BOARD FEET PER ACRE



BOARD FOOT VOLUMES OF SAWTIMBER PER ACRE

	0-1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	TOTALS
PINE																				
DESIRABLE								816	772	462	243	104								2397
UNDESIRABLE								200	181	123	81									585
TOTAL								1016	953	585	324	104								2982
HARDWOODS																				
DESIRABLE								104	134	111	77	68	44							538
UNDESIRABLE								96	110	92	52	68	44							462
TOTAL								200	244	203	129	136	88							1000
PINE & HARDWOODS								1216	1197	788	453	240	88							3982
								3654				328								



maximum sustained production of high-quality timber. Many years will be required to remold the unmanaged forest to the pattern desired, but if proper attention is given to the economic requirements of commercial operations as well as to stand improvement, good management should prove profitable from the beginning and become increasingly lucrative as yields increase in quantity and quality.

The fact that growing stocks often are seriously deficient in quantity has led some persons to infer that complete cessation of cutting operations is a desirable way to build up growing stock. Unless the trees are well distributed and the stands extremely light, for example, under 1,000 board feet or its equivalent per acre, this idea is erroneous. Owing to the irregular distribution of timber in neglected forests, even light average stands include dense groups with surplus trees needing removal. All unmanaged stands contain numerous individuals too poor to continue as growing stock, and even well-managed stands always contain some trees of this kind, which are usually capable of yielding current income if cut, but which are of little value as future growing stock. It must be concluded, therefore, that the ax is the principal cultural tool in forestry and that, to grow good timber efficiently and rapidly, a regime of light and frequent cutting is an essential practice for nearly all stands.

The application of sustained yield can be insured only through correct cutting practices applied to definite units of known area and growing-stock conditions. Sustained yield of a sort is certain to result on each forest unit if each cut removes not more than will be replaced by growth before the next cut. In understocked stands—and these constitute over 90 percent of the forests of the South—the aim of sustained-yield management is to build up the growing stock by currently removing less volume than is added by growth. If possible, not less than 20 percent of the natural growth should be saved for this purpose. In the absence of abnormally serious fires, tornadoes, or insect epidemics, this reserve growth is not lost but is added to the capital growing stock and can be liquidated whenever desired. Like interest on a savings account, growth on wood capital accumulates at a compounded rate.

In placing unmanaged forest properties under sustained-yield management, a policy of light cuttings and short cutting cycles is desirable. Light cuts cause the least disturbance to the balance established in nature, and frequent cuts on the same area provide the means of promptly correcting some of the mistakes of previous cuts and of salvaging insect-infested and other trees lost through natural causes. These light cuts also provide for liquidating financially mature and over-mature trees and for thinning overcrowded stands. A light cut permits a much larger proportion of the accessible forest property to be covered when removing the allowable volume of cut (as determined by the growth on the whole property). Cutting cycles of 5 to 10 years are desirable in second-growth stands.

Most stands of second-growth southern pine are understocked in trees of sawlog size, and the building up of these larger diameter-classes is usually a prerequisite to increasing productivity of southern-pine lands. On the other hand, most stands are proportionately better stocked with natural regeneration, saplings, and pole-sized trees; cutting merely to increase the area available for these size-classes, therefore, is undesirable. In fact, cutting which would divert growth from the larger trees that will be utilized within a comparatively short time to smaller trees that will have no value for many years, is not good management. But if the trees selected for cutting are distributed lightly throughout all merchantable diameter-classes, instead of taken chiefly from the larger sizes (as has been done commonly in the past), the distribution of timber will be shifted from smaller to larger diameter-classes. This shift is more rapid than can be inferred from the average figures of diameter growth because some trees, growing under favorable conditions, increase in diameter at a much greater rate than the average. Owing to this factor, where tree values are similar to those of a recent study, a 14-inch tree worth 41¢ in 1935 may become a 24-inch tree worth $11.42 by 1960 (end of a 25-year period). More significant in current operation is the upward movement of the whole growing stock, which insures at short intervals an adequate yield from each area.

Figure 2 illustrates theoretically how cutting in all merchantable diameter-classes builds up the growing stock in the larger sizes. The stand-structure diagrams illustrate the basal area per acre that it is estimated will be present at the beginning of 5 different cutting cycles. The first diagram shows the basal area per acre of the present growing stock as determined on 1,000 acres of second-growth loblolly and shortleaf pine and hardwoods in southeast Arkansas. It also illustrates proposed improvement cuttings to be made immediately in both pine and hardwoods in the present stand. The second diagram shows the estimated basal area per acre of the stand after 10 years of growth and also a proposed cut of 25 percent of the basal area in each diameter-class. The remaining three diagrams show the estimated growing stock at the end of 20, 30, and 40 years as well as cuts in both pine and hardwood amounting to 30 percent of the basal area in each diameter-class. These diagrams are purely hypothetical and do not represent results of actual measurements under sustained-yield management, but they are based on growth rates actually found in the timber on a 1,000-acre tract in Arkansas.

These diagrams indicate that the total basal area of the timber in the large-sawtimber classes will increase from almost nothing in the present stand to a fairly satisfactory stocking after 40 years and may include trees as large as 32 inches d.b.h. Although these diagrams may not represent the actual growth that will take place, they are fairly conservative in their predictions, and in a general way illustrate the shift in diameter-classes that may be expected when such cutting practices are followed. In the last diagram a suggested "normal" [4] growing-stock distribution for the pine stand is indicated by a curve. This curve is theoretical and its height is arbitrary, but its form is based on the observed distribution of diameter-classes in European stands under intensive selective management for sustained yield.

If all trees to be cut are selected from the silvicultural point of view, progress in building up the volume and quality of the growing stock will be very rapid. Obviously, in any area operated under a given cutting cycle, the removal of crooked, rough, or otherwise undesirable trees—and particularly of inferior species of hardwoods—will leave better trees to grow. For this purpose cuttings should extend currently throughout all merchantable diameter-classes, and it should not be necessary to shift future growth entirely to seedlings and saplings, from which growth can be harvested only in the distant future. Where pulpwood or other cordwood is utilized, light cuttings may be made in the pole-sized trees, removing only those individuals that will not develop into high-quality material. Less frequently recognized in cutting practice is the need for saving many well-formed, vigorous trees in the small-sawtimber group to grow into the large-sawtimber group, and within the latter group to select specimens, exceptional in quality and vigor, to grow into still larger diameter-classes. It is not fully realized by forest owners that most of the volume growth on large trees is on the relatively extensive surfaces of the merchantable portions of the stems; that because of the greater clear-lengths of the stems, most of this growth on the large trees is of high quality; that relative to the amount of ground space occupied, the growth on large trees is much greater than that on small ones; that the large trees are relatively immune from injury by fire; and that the cost of logging and milling per thousand board feet is much less for the large trees. For these reasons the size at which high-quality trees reach financial maturity is far greater than that now generally accepted as a basis for cutting and greater than that now commonly found in second-growth stands. For economic and other (e.g., social) reasons, production must be maintained, but practical cutting operations largely center around the decision of which stems to cut and which to leave. By pursuing a light cutting procedure, the growing stock can be built up in both volume and quality, and the level of the yield can thus be raised materially.

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[4] A normal forest is a standard with which one can compare an actual forest to bring out its deficiencies for sustained-yield management; an ideally regulated or organized forest; a forest with normal increment, age classes normal in size and distribution, and normal stock.

It is evident, however, that yields cannot be continued indefinitely without a satisfactory regeneration of the forest. In most places where shortleaf and loblolly pine forests are protected from fire, adequate pine reproduction may be expected to follow all types of cutting except the very light and the very heavy. In making very light cuts, reproduction is generally both undesired and unnecessary; while in making very heavy cuts, regeneration often fails because the source of seed is reduced severely. Although natural reproduction of pine usually fills openings made by removing individual sawtimber trees, under certain conditions this is not true, and it may be necessary to remove groups of sawtimber trees in order to stimulate regeneration. In the past, heavy exploitation of stands for pine alone left in many places a larger proportion of hardwoods, including many commercially undesirable trees, which, after several years of development, effectively prevent pine from becoming established in the understory or from making satisfactory growth. Studies have shown that girdling, which is effective in killing these worthless hardwoods, usually requires 1 to 5 man-hours per acre, depending on the number and size of trees girdled. Even in stands originally without numerous hardwoods, the heavy cutting of pine timber is often followed promptly by a rank growth of hardwood shrubs and trees to the apparent exclusion of all pine seedlings. Fortunately, on pine uplands this failure in the reproduction of pine may prove to be only partial, as in some cases numerous pine seedlings finally emerge above the brush, develop normally, and, when closely surrounded, even grow into superior trees because of the presence of hardwood associates. Nevertheless, the net result is commonly a deterioration of the forest, owing to the reduced volume of pine timber in the second-growth stands. Surveys have shown this condition to be prevalent over extensive areas now being protected from

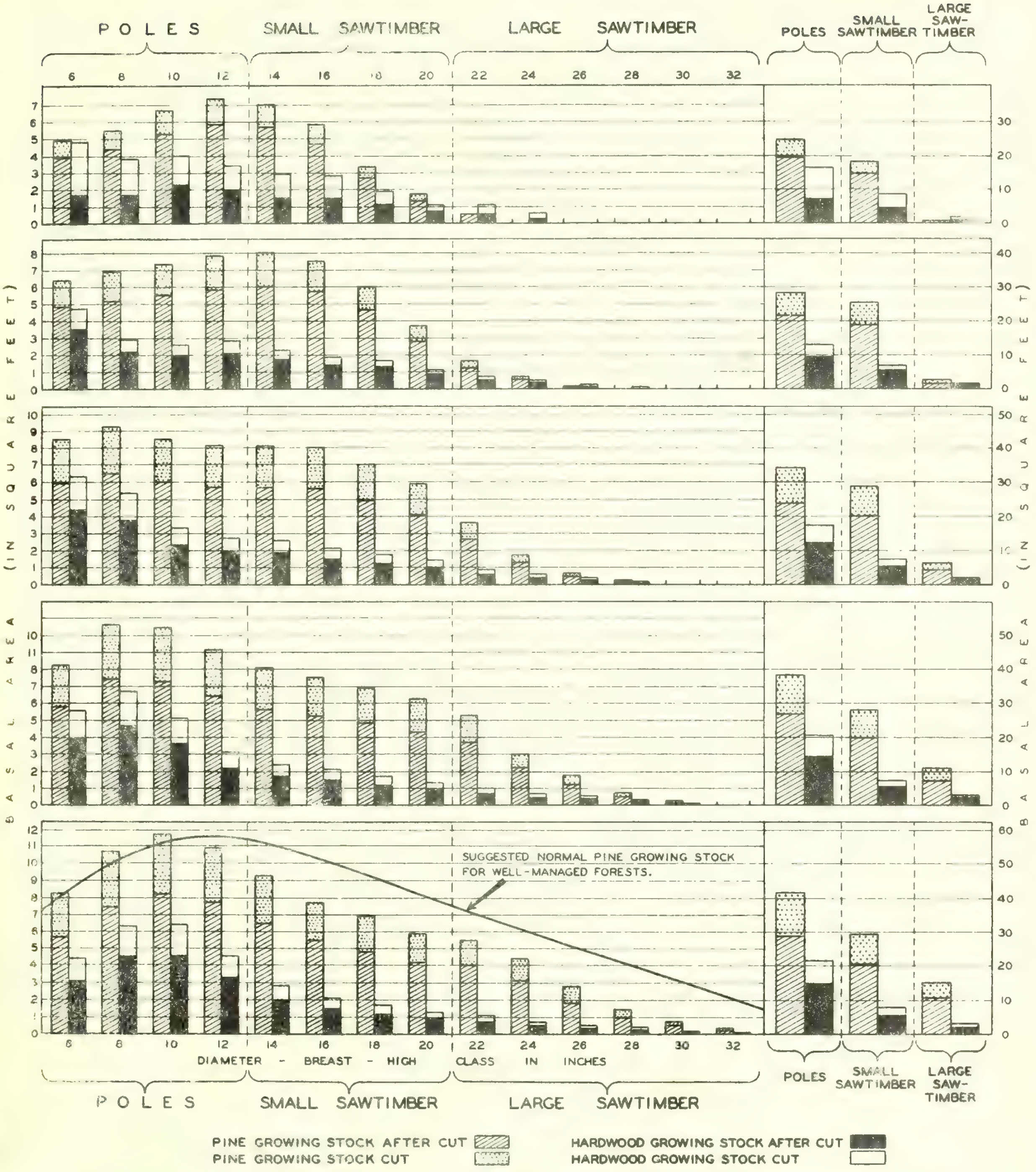

FIGURE 2. - STAND STRUCTURE DIAGRAMS SHOWING PRESENT GROWING STOCK, PROPOSED IMPROVEMENT CUTTING OF PRESENT STAND, AND ESTIMATED GROWING STOCK AND PROPOSED CUTS AT END OF EACH OF FOUR 10-YEAR CYCLES; BASED ON A 20-PERCENT INVENTORY AND INTENSIVE GROWTH STUDY OF 1000 ACRES OF SECOND-GROWTH LOBLOLLY AND SHORTLEAF PINE AND HARDWOODS IN ARKANSAS.

fire. Marked increases in the hardwood component of pine stands cannot be justified on the basis of its acknowledged superiority in adding to the fertility of forest soils. In case the pine fails to emerge, it can be released by cutting the small competing hardwoods, but experience has shown that several release cuttings may be necessary because of the prolific growth of hardwood coppice, and often the benefits from cutting do not pay for the costs. Unless the failure of pine reproduction is extensive and long-continued, no expensive measures are recommended to combat it. The value of forest land is so low that it is often cheaper to "store" inferior hardwoods of merchantable size on the stump and to allow young hardwood stands to grow until they become of value than it is to remove them at a loss.

It is hardly necessary to add that the type and extent of market outlets for forest raw materials has a profound influence on forest management. Thus new uses, which have been developed for several hardwood species previously unmerchantable, have influenced the desirability of these species. Likewise, where only pine products are marketable, or where only sawlogs can be sold, progress in improving the growing stock and yields therefrom must be slower than where outlets permit early removal of small and inferior trees.

The measures necessary to improve and build up the growing stock can be summed up as follows: First, keep each management unit stocked as completely as possible with merchantable trees, so that as much as possible of the productivity of the site is devoted to growth of merchantable timber; second, through light and frequent cuttings continually shift growth from trees of poor form and vigor to better trees; and third, hold the better trees until they are financially mature.

ORGANIZING A FOREST PROPERTY FOR SUSTAINED-YIELD MANAGEMENT

The protection of a forest property against fire and other destructive agencies, the determination of the volume of allowable annual cut based on the yield possibilities of the forest, the subdivision of the property for management purposes, and the preparation of a preliminary plan of management are necessary before controlled cutting under sustained-yield management is started.

Protection of the Forest

Without adequate fire protection in the loblolly and shortleaf pine forest, management for sustained yield is useless, since uncontrolled fires often prevent natural regeneration, and destroy, or at least seriously damage, premerchantable or even sawtimber growing stock. Fire protection involves both the prevention of forest fires and their prompt detection and efficient suppression. Although various degrees of fire protection may be regarded as satisfactory, for the purpose of continued forest production, a reasonable goal limits the average area burned per year to less than 1 percent of the total forest area protected.

Where forest holdings are not well consolidated, this goal may be difficult for an owner to reach independently, but fortunately since forest production and fire protection are very widely recognized as essential to public as well as private interests, cooperative fire protection organized under the State Forestry Departments has been legally recognized (Clarke-McNary law of 1924) in each of the southern States, where it is financed not only by Federal and State appropriations but also by contributions from private owners, varying in amount with the area protected. The cost to the private owner usually is between 2¢ and 4¢ per acre. Because of the small State and Federal appropriations, however, and because of the demand by private owners for protection over large areas, the State is generally not able to protect against all fires under emergency conditions. It is, therefore, essential that the private owners cooperate closely with the State organizations and that they furnish additional fire fighters in case of emergency.

Proper methods of cutting, together with adequate fire protection, normally provide the necessary protection of the forest from insects, disease, and other natural agencies. Except for epidemics, which are rare, losses from these natural causes are generally small, and with light cuts at frequent intervals, infested or seriously infected timber can be removed as a sanitary measure, thus salvaging it together with windfalls or other trees killed outright by these natural agencies.

Determination of the Allowable Annual Cut on the Property as a Whole

The current growth and reproduction of merchantable species of timber on different sites and the resultant changes in growing stock constitute the fundamental basis of practical forest management. They determine the capacity of "forest lands under existing methods of management" to produce on a sustained-yield basis, "as determined from existing growing stock and growth," and hence are of paramount importance.

The remaining second-growth forests which have followed the original virgin timber typically show not only a poor distribution of tree sizes but also a volume of merchantable growing stock that is decidedly subnormal from the standpoint of sustaining adequate yields. Accordingly, the maximum allowable cut for any period from an entire property should not exceed the total estimated growth of merchantable size-classes for a like period. If the growth is largely on small diameter-classes, an annual cut confined to larger classes will deplete the property of growing stock capable of making the most valuable growth and inevitably reduce the value of future yields even if volume be maintained. The forest owner thoroughly committed to practices adequate for building up productivity must either refrain from cutting the equivalent of the total growth or see that the cut is distributed among all merchantable size-classes. As already noted, conservatism in cutting requires another entirely reasonable step, that is, saving a certain percentage of the growth for necessary additions to the growing stock. Saving 20 percent of the annual growth over a period of 20 years should add from 30 to 50 percent (depending on the site) to the total present volume of growing stock and likewise to the subsequent annual growth and yield. If, at the same time, the diameter distribution of the growing stock is improved by continuous careful selection, as discussed hereafter, the value of the yield will increase much more rapidly than the volume. This program of reserving a part of the growth for permanent growing stock also permits more freedom in selecting timber for the current cut.

At first thought, it may seem that owners having sawmills or other plants depending on their forests for logs would be unable to restrict their cut if sustained-yield operations provided an insufficient volume of logs, but with the advent of motor transportation, which makes timber accessible up to 25 or more miles from the sawmill, the log supply can generally be augmented by purchases and the volume requirements thus fulfilled. It should also be noted, however, that in order to avoid direct losses to the forest owner and to take advantage of good market conditions, it is imperative that the cutting budget decided upon permit reasonable flexibility from year to year.

Although light and frequent selective cuttings under conservative management may maintain certain yields on definite units of the property and eventually on the entire property, it is important to know as early as possible the volume of timber that can be cut annually without depleting the growing stock. In the early years of organized management, determination of the volume of allowable annual cut usually must be based on a preliminary estimate or inventory of the total merchantable growing stock and a predicted growth in merchantable volume for the property as a whole.

Despite the desirability of an inventory and determination of total growth, caution is necessary to avoid wasteful and unproductive expenditures for these purposes. The yields of southern pine can be changed so rapidly through good or bad practices that extreme refinement of yield calculations is wholly out of place until a definite and stabilized system of management is in effect. For this reason, it is better to be satisfied at the start with approximations to the volume of growing stock and rate of growth and to concentrate expenditures on development of cultural cutting practices that will build up production. Many forest owners have timber cruises, which, although usually lacking in details as to size and quality of timber, suffice for preliminary surveys of growing stock.

If information from recent cruises is not adequate, the cheapest and most accurate method of obtaining the minimum information needed is by a line-plot survey conducted by a competent technician. This consists of running parallel compass lines at regular intervals to gridiron the property and taking accurate measurements of all trees of merchantable size on small circular plots (usually 1/5 or 1/4 acre) at regular intervals along the lines. The spacing of the lines and plots (often decided largely on the basis of available funds) depends on the size of the property, the uniformity of the timber stands, and the degree of accuracy desired. On forest properties composed chiefly of second-growth stands of pine, the spacings shown in table 1 will generally be satisfactory for the restricted purpose here contemplated.

Table 1. Suggested spacing of lines and plots for surveys on properties of various sizes

Size of forest property	Interval between lines	Interval between 1/5-acre plots		Portion of total area sampled	Approximate number of plots
Acres	Miles	Chains	Feet	Percent	
100,000	2	10	660	0.125	625
50,000	1	10	660	0.25	625
25,000	1	5	330	0.50	625
10,000	$\frac{1}{2}$	5	330	1.00	500
1,000	$\frac{1}{4}$	2	132	5.00	250

Note that, unlike the 10- to 20-percent inventories sometimes used for locating and mapping timber types and stand conditions, the area actually covered in sampling is small, indicating a relatively inexpensive cruise. From the results obtained, the average number of trees, the basal area, the volume in cubic feet, and the volume in board feet per acre all can be sufficiently well determined. Totals for the entire property are obtained, of course, by multiplying the results for the average acre by the total number of acres. It should be emphasized, therefore, that results based on the field work as set up in the above table will be sufficiently accurate only if applied to the entire property. Obviously these non-intensive timber cruises will not show the amount of growing stock on smaller tracts such as sections or other small units of management. It must be remembered, however, that the sole object of such a preliminary survey is the blanket determination, within reasonable limits of error, of the aggregate timber volume on the forest, to be used as a basis for arriving at the allowable gross volume to be cut currently from the whole property.

Owners wishing to place unmanaged forest properties under sustained-yield management seldom possess accurate information on the growth rates of their timber by species and size-classes. Consequently, in order to determine the approximate current yielding capacity, on which to base the volume of the allowable annual cut, growth studies are generally necessary. Volume growth naturally varies with the productivity of the site and with the amount and kind of growing stock. On better sites, and in second-growth loblolly and shortleaf pine stands as now stocked, annual growth amounting to 100 - 400 board feet per acre is common.

The rate of diameter growth is by no means stable in typical young understocked forests, but tends to decrease progressively as the stands gradually close in, since competition between growing trees increases with their size. This natural deceleration of diameter growth can, and usually should, be reduced or eliminated by applying the cutting practices recommended in this paper. Such cutting may automatically raise the average growth rate merely by removing slow growers, regardless of any acceleration in the growth rates in reserved trees. The maximum possible rates of diameter growth, however desirable on clear-stemmed, individually selected crop trees, are not desirable for the reserved stand as a whole, because the fastest diameter growth is commonly found only on commercially undesirable,wide-spreading trees of exceedingly poor form and quality. Therefore a moderate average rate of diameter growth permits maximum yields in value of stands. With equal rates of diameter increase, a large tree produces much more wood than a small one, but because of their size, the percentage rate of volume growth is less for the larger and more valuable trees. Accordingly, the existing volume growth of stands should be increased primarily by increasing the growing stock or basic wood capital rather than by attempting to increase materially its percentage rate of increment.

The annual volume increment in shortleaf and loblolly second-growth stands commonly varies from 4 to 9 percent of the growing stock, being less on poorer sites and in the heavier, better-stocked stands. Some timber owners have attempted to estimate the percentage of growth merely by assuming that the lands and stands to be managed are similar to others of known capacity for growth. Such gross approximations, which are unreliable at best, and which will be found inadequate for most owners who seriously contemplate forestry, should never be trusted until checked against growth data gathered from the timber property itself.

As has been noted already in the preliminary determination of growing stock as a basis of yields, it may be justly held that refinement in the first studies of growth is unwarranted, because the amount of such growth obtainable under management in the South can be changed readily and materially. Nevertheless, rates of growth can affect yields so vitally that they demand serious consideration; and forest owners should have some knowledge of general principles and methods of growth study, even though the more accurate determinations be tasks for competent foresters.

A common procedure in forecasting current growth in merchantable volume a decade in advance is to contrast the volume of timber stocks as computed from existing stands and from the stands as they are predicted to be at some future time, thus estimating the probable net increases in volume. If the survey used for estimating the volumes of the total timber stands covers the entire forest property systematically, it provides an excellent opportunity to study the growth of timber. This can best be done by measuring the radial growth during the past 10 years on all of the merchantable trees found on small circular plots, e.g., 1/40 or 1/50 of an acre, within each of the larger plots used to record growing stock. Also all trees of specified premerchantable size-classes found on these small plots and expected to grow into merchantable size during the next 10 years, should be sampled to determine their radial growth, which can be measured on a core of wood extracted by an increment borer.

The method of forecasting a future forest stand is of interest. A slight reduction is made in present numbers of trees to allow for expected mortality during the period.5/ The approximate movements of trees out of each class and into certain larger size-classes is then tabulated. This must be done not only for each merchantable diameter-class but also for those premerchantable sizes expected to become merchantable within the decade. This so-called "in-growth," which is a relatively large item in thrifty second-growth forests, often amounts to 30 to 50 percent of the total volume growth. The forecast rests upon the rates of diameter growth found typical of the various sizes of trees, but it may employ only averages read from curves, thus disregarding the intricate dispersion of growth rates of individual trees. Also growth rates of wood as measured inside the bark require a slight correction to make allowance for increases in bark thickness. The future stand could be forecast very simply by accepting these average rates of wood and bark increase as the growth of all trees in a given size-class. A better way, however, is to recognize the approximate effect of dispersion of growth rates within size-classes. This can be done, even without a true measure of such dispersion, by relying on the following hypothesis of tree movement: The number of trees which grow from a smaller into a larger diameter-class bears the same relation to all trees in the smaller class that the average growth rate (in inches) for that smaller

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5/ No precise way of judging mortality rates is known, but in well protected stands of southern pine the loss in merchantable growth over a short period like 10 years is usually quite small. Furthermore, where dead trees can be promptly salvaged, none of the past growth is sacrificed, the loss being confined to that remaining portion of potential future growth not automatically transferred to desirable neighboring trees.

class bears to the diameter-class interval (in inches). Thus with a 2-inch diameter-class interval, the process works out as shown in table 2.

Table 2. Approximate hypothetical change of distribution in size-classes of trees of varying growth-rates

Growth in d.b.h.	Movement factor [1]	Trees moving up two classes	Trees moving up one class	Trees remaining in present class
Inches		Percent		
3.8	190	90	10	0
3.0	150	50	50	0
2.4	120	20	80	0
2.0	100	0	100	0
1.0	50	0	50	50
0.6	30	0	30	70

[1] Derived in each case by multiplying the growth in inches by 100 and dividing by the class interval in inches. Thus for these 2-inch classes the movement factor is obtained by multiplying the growth figure by $\frac{100}{2}$ or 50.

The number of trees moving ahead is then obtained by applying these percentages to the number of trees present in each class. The total growth estimated for the property as a whole during the 5- or 10-year period is the difference between the volume of the present stand and the volume of the predicted stand.

This method of predicting growth rests upon two assumptions: (1) the variation of tree diameters is uniform within a given diameter-class, providing a nearly equal representation of all sizes within the class, and (2) a constant rate of increment—represented by the average for a given diameter-class—maintains this uniformity as each successive group of trees grows into larger diameter-classes. Since these assumptions of uniformity in size distribution and constancy of growth rates within classes are incorrect, inaccuracies resulting from the use of this method may be expected. Figure 1-A shows that the trees in the stand illustrated are so distributed as to form a J-shaped frequency curve. In such stands, because the smaller trees in each class are more numerous than the larger ones, the errors resulting from the first assumption would be positive. In other words, when using this method to predict the future stand, too many trees are moved forward from each diameter-class; this results in an accumulation of small errors and a consequent exaggeration of volume growth. The total error might be appreciable if the development of saplings and pole-sized trees were being forecast, because of the relatively great abundance of the smaller trees in this portion of the growing stock. For the sawtimber portion of stands, however, like the one illustrated in figure 1-A, the error in the final result may be well within permissible limits of total error in forecasts of this kind.

Further refinement of method, to allow for variation in growth rates, requires that the timber cruisers bore a larger number of trees. Enough samples of wood and bark growth must be obtained to permit computation of the percentage of trees which remained in their initial class and the percentages which moved up one or two classes during the previous 10 years. Such information worked out separately for each diameter-class provides a much truer picture of actual tree movements and permits of more precise forecasts.

One way of applying this percentage method to a single diameter-class may be illustrated as follows: Suppose, for example, predictions are desired for growth during a period of 10 years of the trees in the 14-inch diameter-class, if the average acre bears 12.18 trees, of which 12 are expected to survive, and if one-sixth remain in the 14-inch class, two-thirds move into the 16-inch class, and the other one-sixth move into the 18-inch diameter-class. The present volume of these trees is 12.18 x 154 (board-foot volume of 1 tree) = 1876 board feet. In 10 years these trees attain the following volumes:

	Board feet
the 2 trees remaining in the 14-inch diameter-class (154 board feet each)	308
the 8 trees in the 16-inch diameter-class (227 board feet each)	1816
the 2 trees in the 18-inch diameter-class (308 board feet each)	616
Total volume at end of 10 years	2740
Volume at beginning	- 1876
Growth of 14-inch diameter-class during 10 years	864
Average growth of 14-inch diameter-class in 1 year	86.4

After treating each diameter-class in this manner, including the larger premerchantable classes, the figures may be added to show the volume growth expected from the average acre of the forest.

In view of the obvious need for economy in preliminary studies of growth, the superiority of the more accurate percentage method may be questioned because of the much larger number of trees that must be sampled by boring. Increased knowledge of the dispersion of growth rates in the forest, however, may be useful in other ways, particularly in the selection and development of crop trees by cultural methods.

Subdivision of the Property for Management Purposes

Actual management for sustained yield must be applied to definite units of known area and growing-stock conditions. Before cutting is started, a forest should be subdivided into blocks and compartments for administration and management. Blocks usually exceed 50,000 acres in area and are used to subdivide large properties for better administration. Compartments are the real units of management, and simple but adequate accounts of changing growing-stock conditions and yields should be kept for each.

Where rectangular public-land surveys exist, some owners keep all records by legal subdivisions of 40 acres each. This, however, leads to an unnecessary multiplicity of records; and the quality of the records, with the possible exception of those for small properties of not over 5,000 acres, is certain to suffer. In other cases the land owned in each legal section is taken as the unit area for making contracts and records. This has advantages where ownership readjustments are still taking place. Where stable ownership of considerable areas has been attained, units of 500 to 2,500 acres, bounded by a combination of roads, streams, and land lines, not only may be handled very easily in all forest operations but also will reduce the number of records to a minimum. It may be mentioned that a well-devised road system is necessary if the lowest costs possible are to be attained by motorized logging; and if this road system can be surveyed before cutting begins, it is desirable to use some of the primary roads, even though they are not yet constructed, as the boundaries of compartments. All compartment boundaries should be plainly marked on the ground and accurately mapped.

It is advantageous to segregate hardwood bottomlands in separate compartments, but it is not necessary that pine stands be thus separated by stand conditions. Formerly it was believed that management subdivisions should, so far as possible, contain areas all in the same age-class, but experience does not justify giving any weight to this factor in irregular forests. Because of the varying stand density and the consequent range in tree sizes, much timber may be of even age but decidedly uneven in development and character. This applies both to individual trees and to groups in the stand. In consequence, one portion of the area may become ready for regeneration before others, and thus the uniform character of even-aged forests is broken up under selective timber management. After some years of management, all pine stands will be composed of trees of many sizes and age-classes; and compartments that were established to include certain stand conditions will lose their distinctive character. Since compartments are the units of management, they should be very carefully selected for permanence and with the definite purpose of establishing an adequate but simple system of permanent records.

Preparation of Preliminary Management Plan

European forests and those of other countries where forestry is well established are almost invariably managed in accord with written plans, which prescribe the total amount of the annual cut, allocate the cutting to the various devisions of the forest property, and prescribe other operations usually in a rather rigid manner. It must be remembered, however, that these rigid plans are generally for forests which have been under management and for which adequate records of the yield and growing stock have been kept for a long time; they therefore represent reduction of this long experience to a written form, as a guide for future management.

As American forests have not been subject to sustained-yield management for any long period, the attempt to make plans of this nature even for public forests has been none too successful. Owing to the rapid movement of the business cycle, to changing standards in utilization, and to other factors, it has generally been found that detailed recommendations to be carried out from year to year form more of a hindrance than an aid to forest management. No plans that reduce the financial returns from the forest by too strict limitation of the cut when prices are high, or by prescribing continued marketing of products when they are low, can be considered a real success. Sustained-yield management does not preclude sufficient flexibility in the annual cut to permit the forest owners to realize on a good market by cutting more of the growth and to avoid poor markets by cutting less of the growth. The sound rule for the forest manager is to "save growing stock in bad times, and save money in good times," so that the business is equalized and stabilized throughout the years. Money saved in good times can be used in bad times to make necessary forest improvements in lieu of cutting timber to create employment.

The type of management plan required, therefore, is one with a flexible application. At the beginning such a plan may consist of a careful collection of all pertinent and accurate data regarding stands, market outlets, and other available information; a mapped compilation of all available ownership data, compartment boundaries, transportation facilities, drainage lines, and forest types; and a statement of policy, which may include such items as the following:

1. Each periodic cut shall aim (a) to remove trees less valuable for further growth, including, so far as possible, the insect-infested, diseased, and crooked trees, and (b) to save for the reserved stand, vigorous, clear-stemmed trees in order to improve the quality of the growth.

2. The total volume of the periodic cut in any forest division shall be small enough so that the reserve growing stock can restore by growth during the ensuing cutting cycle as much or more volume as was removed (automatic sustained yield).

3. Light and frequent cuttings shall be practiced wherever possible.

4. Adequate records of the yield from each compartment and of the reserve growing stock left after each cut shall be kept as a basis for future planning and management.

The records of changes in growing stock and yields for each management subdivision are designed to register the continuing experience of management and thus form the basis for progressively more accurate planning as time goes on. With such a flexible policy of management in the hands of capable managers, constant advance can be made.

FORESTRY PRACTICES UNDER SUSTAINED-YIELD MANAGEMENT

All of the foregoing is explanatory or preliminary to the actual forestry practices necessary to derive satisfactory current returns from forest holdings, combined with continuous improvement of the forest property. The organization for protection against fire and other destructive agencies, the determination of the allowable cut, the subdivision into management units, and the preliminary management plan all apply to the property as a whole. From this point on, management is applied to definite units of known area, designated as compartments (see page 18).

It is in the selection and cutting of trees and the management by compartments that most of the budget provided for forest management should be expended, because better and less expensive methods of extracting timber from the forest and of delivering it to the mill or market are part and parcel of good forest management. Thus if the field budget is properly expende it will save management expenses of equal or greater magnitude, such as the unnecessary inventories already described.

The first steps towards sustained yield are: to stop indiscriminate, wasteful uses of immature timber; to eliminate unprofitable size-classes from the sawtimber cut; and to seek self-supporting outlets for surplus and inferior elements within smaller size-groups. All of these measures increase revenue; at the same time they conserve existing capital and pave the way to increased productivity and to correspondingly increased values in the future. Therefore, good forestry practices, inasmuch as they are the sole preventive of many unnecessary losses of current income and capital values, reduce expenses rather than increase them.

Selecting Areas to be Cut

After the total allowable cut has been determined for the property as a whole, the next step in forest management is to decide upon the order in which compartments will be cut. Although this order must conform to good logging practices, which reduce costs to the minimum, it should not be rigidly binding, since changes in market conditions may necessitate changes in the volume of future annual cuts and also in the nature of the materials to be cut. It is, therefore, advisable to designate the areas for cutting only 1 or 2 years in advance rather than for 5 or 10 years.

Each compartment, except those without sufficient merchantable timber to make logging financially feasible, should be cut lightly at intervals of 5 to 10 years. Because of the relatively flat topography and the well-developed system of public roads the timber on most forest properties in the South is readily accessible for truck logging, but a well-planned system of private roads on the property is necessary if the lowest logging costs are to be attained and if logging is to be carried on during the rainy season. Selective cutting of 1,000 board feet or more per acre is generally recognized as feasible, and studies of truck logging have shown that as little as 500 board feet per acre can be removed without increasing logging costs appreciably. With markets for pulpwood and fuelwood now established in many parts of the South, cutting of stands for these products is common and profitable.

The cut during the first year of management should include (within economic limits) any compartments with dangerous insect infestations, with windfalls, or with trees severely damaged by recent forest fires. It should also include (within limits of the allowable cut, computed as explained in the preceding chapter) those compartments bearing the greatest volumes of financially mature (or overmature) timber as well as those younger stands seriously in need of improvement cuttings because of overcrowding or other conditions unfavorable to growth and future yields of high-quality material.

Intensive and costly surveys are not necessary in order to locate those compartments in need of immediate cutting. Practically every operating company has information as to approximate volumes and locations of merchantable timber on its holdings. Recent purchasers of timberland undoubtedly have this information. Logging superintendents and land surveyors usually are familiar with timber conditions and often have made maps giving estimates of volumes by definite areas. By calling upon all available sources of information and through close cooperation with the logging division, the forester, who should have the responsibility for selecting the compartments for cutting, and who should be familiar with all parts of the property, can plan the cut so as to make logging economical, and at the same time cut those compartments which are most urgently in need of cutting.

Selecting and Marking Timber to be Cut

Often the initial step in better forest management has been the issuance of instructions to workmen regarding the diameter limits of trees to be cut in selective cuttings. This may bring about minor improvements over old practices, but the results are invariably inadequate, because the timber to be cut has not been properly selected. Selection of timber for cutting is of primary importance both from the marketing standpoint, and from the standpoint of the reserve stand, which determines the production rates of the immediate future. Proper selection is, therefore, the heart and foundation of good management practice; it is not obtained from arbitrary size limitations and should not be given secondary consideration. Real improvement of cutting methods, therefore, demands that every tree be marked before cutting is allowed. Except in the case of the owners of small areas, who may do this work personally after studying the problems involved, marking should be carried out only by, or under the supervision of, a competent forester.

Selective cutting is a common term which is used to include all types of tree selection, whether for thinning in young stands, for making improvement cuttings in stands burdened with inferior species or individual trees, or solely for marketing. From the economic standpoint, it is most desirable to cut large trees at the time of their financial maturity, which is defined as the time when the individual tree or stand will no longer make an economically satisfactory increase in volume, quality, or price. By the same definition, financial maturity has arrived for surplus trees of any size which will not earn satisfactorily if left standing. In second-growth southern pine stands, financial maturity has seldom been reached by the larger and better trees, but it has generally been reached by large numbers of surplus trees in young stands, by inferior species of hardwoods, and by the rougher and more defective sawtimber trees of all sizes.

Another consideration is the minimum size of tree that will pay its way. In cutting pines for pulpwood, the economic minimum size is about 6 inches; while for lumber, operators of the larger mills find that a pine 13 inches d.b.h. is ordinarily about the smallest tree that will yield lumber of sufficient value to yield a profit over the costs of production. Operators of small mills, however, can often cut smaller trees without financial loss. For hardwoods the minimum size for profitable handling is usually somewhat larger than for pines. Frequently, however, cutting practices will be determined by manufacturing or other market requirements and by the financial needs of the forest owner. The marking program should, therefore, be one that removes gradually the inferior elements of the stand, taking only as many of the larger and better trees as necessity requires. In other words, a sound marking policy must consider both the cultural improvements of, and the economic returns from, the forest property.

So many ways exist in which to improve or impair the stand by selective processes that only certain aspects can be touched on here, in addition to what has already been said under "Improvement of growing stock" (page 5). It is very difficult to prescribe effective marking rules which can be applied t the great variety of conditions found in irregular second-growth stands of loblolly and shortleaf pine and hardwoods. No guide to marking procedure can be of any practical use unless it is worked out in the woods and is based upon the actual conditions existing there. This means that any man doing effective marking must be one of seasoned judgement who knows the quality and value of timber products that can be produced from various species, sizes, and types of individual trees; who is able to recognize the thrifty and healthy individuals; and who understands what environment constitutes optimum growing conditions for pines and hardwoods. This does not mean that intelligent and alert men who are not technically trained cannot be taught to mark properly, but it does mean that a capable and experienced forester is essential for training and supervising these men and for solving new technical problems as they arise.

The objective in marking the allowed annual cut should be to leave the stand in the best condition possible for future growth by reserving financially immature trees and at the same time to make the current operations yield some profit. Merchantable trees to be marked for cutting may be classified, beginning with those to be removed first, as follows: (1) pines and hardwoods infested with insects or seriously infected with fungus diseases; (2) trees which will produce little or no volume growth and which probably will not be present at the time of the next cut, including badly suppressed trees, leaning trees, and trees with bad fire scars; (3) poor-quality trees that because of crook, short body, or limbiness will produce only growth of low quality; (4) overcrowded trees in dense stands that are seriously retarding the growth of better trees; (5) inferior species such as black jack and post oak, red maple, and other hardwoods that have a very limited market as sawtimber; (6) other financially mature and overmature trees; and (7) when cutting is absolutely necessary to satisfy the financial needs of the forest owner, trees approaching financial maturity. Where necessary to choose one of several trees, the one whose removal will result in more uniform spacing or in maximum improvement of the growing stock should be marked. Although white and red oaks are very valuable species on many sites and although other hardwoods with clean, sound, marketable logs may also be reserved, in general pines should be left rather than hardwoods.

The amount of the cut on a given compartment must be strictly limited to prevent further impairment of already deficient growing stock and to insure a minimum of interference with current growth. This amount depends upon the volume and character of the growing stock, the productive capacity of the site, and the length of the period before the next cut. Preferably, no more than 25 to 35 percent of the volume of the growing stock should be removed from a compartment at any one cut, but this usually means heavy cutting in some spots and lighter cutting in others. On fairly good sites, where the annual growth amounts to about 6 percent of the total volume of the sawlog growing stock, a cut of 25 percent of this growing stock usually can be restored by growth within about 5 years; likewise, a cut of 45 percent of the sawlog growing stock can be restored in about 10 years. If 20 percent of the growth in each case is reserved and added to the growing stock, the cut for the 5-year cycle should remove only 20 percent of the total sawlog growing stock and for the 10-year cycle only 35 percent. Skillful selection of the trees to be cut not only should increase the quantity of the growing stock but also should improve the quality and distribution of size-classes in the stand.

Controlling Cutting Operations

Because their contribution to forest productivity is not commensurate with their costs, it has been recommended that expensive general inventories be avoided. The savings thus made should be available for careful determination of the growing stock and the allowable cut on each compartment and for controlling this cut.

The total cut, as stated above, should generally not exceed 80 percent of the net growth for the next cutting cycle. In its simplest terms, the net growth on a compartment is the difference between the volumes of merchantable timber at the beginning and end of the cutting cycle. For the first cut, however, no records of stands 5 or 10 years ago are available for comparison with present stands in determining net growth. It will therefore be necessary to accept, as a rough guide for marking, a definite percentage of the total merchantable growing stock as the allowable cut, basing this percentage upon growth and stand data collected in the preliminary survey of the whole property. The forester in charge of the marking, however, should be free to use his expert knowledge and best judgment in raising or lowering this percentage, his decision being based upon actual stand and site conditions on the area being marked.

Since in marking sawtimber to be cut, all of each compartment must be covered by the marking crew, very little extra expense is involved in tallying by diameter-classes, major species-groups, and (possibly) quality classes the sawtimber trees marked for removal and also those trees (over 9 inches d.b.h.) reserved for further growth. A complete inventory of this nature is the most effective means of controlling marking.

The marking and field recording is performed by 4-man crews, in each of which an experienced leader directs the marking and records inventory data as called out by two markers who must be competent woodsmen and who should have sufficient education to qualify later for crew leaders. The marking which is done with white or other bright-colored paint, is greatly facilitated by using hand-pressure (grease) guns capable of projecting a fine stream of paint to about 20 feet. The fourth man runs the compass, delimits the marking strip, and makes a map showing drainage, transportation facilities, and forest conditions. The crews should be directed by an experienced and capable forester. Between 40 and 80 acres of second-growth pine can be marked, inventoried, and mapped by an experienced crew in a day, the cost usually falling below 10¢ per M board feet of cut. With a field inventory taken in this manner, it is possible for the leader to check constantly the percentage of trees within each diameter-class marked for cutting and thus keep the marking within prescribed limits. At the same time a very accurate inventory is obtained of the stand reserved for future growth.

It is from this reserved stand that the cut at the end of the next cycle (5 to 10 years later) will be made. Unless the compartment is well stocked, this cut should again reserve at least 20 percent of the net growth to add to the growing stock. The volume of this net growth can be obtained by taking the second complete inventory, computing the volume of the merchantable timber (over 9 inches d.b.h.) just before cutting, and then subtracting from this volume that of the reserved stand inventoried at the time of the last cut. It is not necessary that this second inventory be made and the allowable cut determined before the marking for the second cut is done, but, as was the case for the first cut, the marking and inventory should be done at the same time, thus making it unnecessary to cover the same ground twice. Marking before the determination of the allowable cut may result in cutting a little too much or, on the other hand, in reserving somewhat more timber than is necessary. With skilled crews experienced in marking the same type of timber on other parts of the property, the volume marked for cutting can be made to approximate the volume of growth, or a certain percentage of it, if some growth is reserved. After the inventory of marked and of reserved trees has been completed, the discrepancies between volumes of growth and cut can be computed. A study of these discrepancies will enable the leader of the marking crew to achieve greater precision in marking and to approximate the desired cut more closely when marking trees in other compartments.

It is a relatively simple office task to make a permanent record for each compartment of the results of the tree inventory by diameter-classes and major species-groups under three headings, namely, the stand before cutting, trees marked, and trees reserved. The basal area and the sawtimber volume should also be computed and recorded.

In addition to the records based on the inventory, the volume of sawlogs, cordwood, etc., as derived from log-scaling or other measurements used in dealing with contractors, transportation companies, and purchasers of forest raw material, should be recorded for each compartment.

It is clear that this simple record system can be operated with a minimum of effort and at a very low cost and that, under effective business management, it can be maintained indefinitely. Thus, over a period of several cutting cycles, experience can be accumulated gradually and made to produce both increasing volume yields and increasing financial returns. An effective aid in utilizing such experience is graphic representation of the basal-area figures for the stand before cutting, of the cut, and of the reserve stand at the end of each cutting cycle on the average acre of any compartment (see fig. 2). As these diagrams accumulate, they will indicate graphically any marked changes in volume or in diameter-class distribution, whether for the better or worse.

Improving Young Stands by Cutting

The building of many new pulp and paper mills is establishing markets for pulpwood throughout most of the South. The low price paid for pulpwood, however, should discourage the good manager from selling his stumpage for this product if his timber has a present or a potential value for poles, piling, or sawlogs, since stumpage suitable for these higher-grade products generally brings a much greater price.

If there are ample outlets for pulpwood and other cordwood materials, it is obviously a simple matter to include in cutting operations as many surplus trees from the pole group and as many inferior trees in all timber classes as desired; then progress in improving the growing stock may be rapid. Over much of the South, where lack of a market inhibits removal of small or inferior hardwoods and a market for pine pulpwood is not yet available to all forest owners, often a slow rate of stand improvement must be accepted. Although establishment of more paper mills and the careful development of local fuelwood outlets may assist materially in relieving forest stands of these elements, it is inadvisable to mark heavily even in the smaller size-classes or among the inferior trees and species, except in spots where regeneration is definitely needed and can be obtained from favorable species.

The cutting of pulpwood or other cordwood materials is generally a distinct operation from the logging of sawtimber and should follow such logging immediately, in order to utilize the tops of felled sawtimber trees while they are still acceptable to paper companies and other purchasers. At the same time that these tops are utilized, standing trees severely injured in logging, and trees whose removal will improve the quality and also the spacing of the residual stands, should also be cut for pulpwood or other cordwood products.

In dense young stands, such as often come in on old fields, and also in second-growth stands which will not be cut for sawtimber for several years, thinnings and improvement cuttings for pulpwood and other cordwood material are desirable to improve the quality and reduce the density of the growing stock, and to obtain a current income to help meet taxes and the costs of administration and protection, thus lessening the need for heavy cuttings in sawtimber. This permits the larger size-classes to be built up more rapidly and hence hastens the time when a large proportion of the growth will consist of merchantable material of high quality.

The cutting in each compartment for pulpwood and other minor products from pole stands and from inferior trees must not be left to the discretion of the cutters, but each tree to be cut should be first marked by a skilled and experienced man; one man, using a hand-pressure (grease) gun to spray paint on trees to be removed, is probably most economical. Generally in pole-sized timber it is not necessary to tally either trees marked or trees reserved, but the same principles of tree selection that are used in marking sawtimber apply in marking cordwood material, which can usually be marked at a cost of less than 5¢ per cord of material cut. In making thinnings, usuall the largest trees, which are rough and hence poor potential sawtimber, the badly suppressed ones, and many others whose removal is necessary to obtain the proper spacing of the reserved-crop trees, are marked. In improvement cuttings, growth is shifted to high-quality trees by removing the diseased, crooked, and other undesirable trees. In all cases where merchantable material is removed, marking should be conservative, and only those trees should be taken which will not increase in volume, quality, or value at a satisfactory rate, since it should be remembered that the small trees of the present must supply the crop trees of the future and since every effort should be made to produce only high-quality, valuable trees.

FINANCIAL POSSIBILITIES OF SUSTAINED-YIELD MANAGEMENT

Profitable Cutting Operations

The first requisite of good management is that the timber removed shall yield a reasonable margin (preferably a wide one) of returns over costs. Under selective management the financially mature timber is removed first and the forest is brought gradually to a high state of productivity by eliminating the least productive part of the growing stock. All of the growing stock contributes to growth, but the more valuable timber is the chief source of the current cut. The average return per M board feet of the cut therefore far exceeds the average possible conversion value per M board feet of the total merchantable growing stock. This means that current earnings on the realizable capital is far in excess of the current growth-rate; and it is therefore essential for profitable management that the larger trees and higher qualities be conserved so that the later cuts can include a large proportion of timber with values above the average of the growing stock. Thus, by maintaining the growing stock, there are no depletion costs to be charged off against the annual cut. Furthermore, by maintaining a fair degree of density in the merchantable size-classes, diversion of an excessive portion of the productive capacity to surplus regeneration and premerchantable timber, such as followed the heavy cuts in virgin timber, can be avoided.

Studies made in 1935 by the Southern Forest Experiment Station of conversion values of trees by sizes and major species-groups show that the values per M board feet of larger trees is much greater than for smaller ones. They also show that logging, milling, and other production costs per M board feet are considerably less for large trees than for small ones. The stumpage conversion value per M board feet for second-growth shortleaf and loblolly pine, that is, the difference between the selling price of lumber and all costs of production, was $1.43 for 12-inch trees, $4.73 for 16-inch trees, $8.00 for 20-inch trees, and $11.42 for 24-inch trees. It was also found that selective logging with trucks was feasible without constructing special roads except in very wet periods, and that a cut of as little as 500 board feet per acre increased costs per M board feet very little over that of heavier cuts. Evidently management that after the first cut removes mostly the larger trees, which are financially mature or nearly so, yields greater profits than clear-cutting, which necessarily must include some trees utilized at a loss. Studies in second-growth stands have further shown that the percentage of the higher grades of lumber resulting from selective cutting were not much less than those obtained from clear-cutting of virgin timber, because, even under the best management, only a small percent of the volume cut need come from defective, crooked, and otherwise low-quality trees, removed a few at a time to improve the stand. Except in open-grown old-field stands, the quality of the trees in second-growth stands is surprisingly high, but the percentage of trees in the large-sawtimber classes is small.

Integrated Utilization Helps Sustain Yields and Profits

Integrated utilization, which provides for the highest and most profitable use of each tree and all portions of each tree, is an important factor in increasing returns under good forest management and should be developed as far as markets will permit, inasmuch as by this type of utilization the largest possible number of workers is employed and the largest profit returned to timber owners.

In the shortleaf and loblolly pine region, several large lumber companies are practicing integrated utilization. Their primary products are high-grade lumber and timbers cut from choice logs, and lower grades of lumber and timbers from poorer logs. The lower-quality top logs of pine are profitably cut into lumber by some companies, by using short lengths in remanufacture, while other companies not equipped for such a high degree of utilization, often find they can make more profit by cutting top logs into pulpwood. Pulpwood is sometimes cut from tops of felled sawtimber trees, but a very small yield or none at all is obtained from the larger trees because of the difficulty of splitting and the high cost of lopping off the large limbs. Pulpwood is also cut from trees removed in thinnings and in improvement cuttings. For tops and inferior stems of hardwoods there exists a limited market as chemical distillation wood and fuelwood. Some pine trees are also cut for wood-preserving plants that treat poles, piles, ties, and fence posts.

Studies of integrated utilization of shortleaf and loblolly pine show that the value of stumpage varies considerably for the different products cut. For example, pine sawtimber stumpage currently varies from $3 to $9 per M board feet or (using a converting factor of 150 cubic feet per M board feet) from 2¢ to 6¢ per cubic foot; while pulpwood varies from 40¢ to 80¢ per cord or (using a converting factor of 80 cubic feet of solid wood without bark per cord) from ½¢ to 1¢ per cubic foot. Hardwood sawtimber stumpage varies in value from 2¢ to 4¢ per cubic foot, and chemical wood has nearly the same value as pulpwood. Peeled pine cut for posts, poles, and piling varies in value from 1¢ to 8¢ per cubic foot. It is readily apparent, therefore, that sawtimber being sold for only ½¢ per cubic foot might better be cut into pulpwood and that the forest owner who sells sawtimber stumpage, worth 4¢ per cubic foot, for pulpwood, worth only 1¢ per cubic foot, is receiving only about 25 percent of its marketable value. On the other hand, the owner who sells his sawtimber stumpage to a sawmill operator and then sells his pulpwood and chemical wood (from tops, thinnings, and improvement cuttings) obtains the full stumpage value of his timber.

Estimated Costs and Returns from Continuous Management of Second-Growth Stands

Investigations made by the Southern Forest Experiment Station indicate that the management of shortleaf-loblolly pine forests is financially profitable, the amount of profit derived depending upon the volume and quality of the present growing stock, the productive capacity of the site, the available markets for forest products, and the efficiency of the management. While the net returns per acre per year from heavily depleted and poorly managed forests are very small, well-stocked and efficiently managed properties yield maximum annual returns of $5 or more per acre. Reasonably good management of average stands under existing markets should yield a net income of $1 per acre per year.

A compartment of 1,000 acres in southeast Arkansas with typical second-growth sawtimber is described here to illustrate the financial possibilities of management. The original timber stand was cut heavily about 25 years ago. A recent cruise of this property shows 2,982 board feet of pine (over 13 inches d.b.h.) per acre, 1,000 board feet of rather poor-quality hardwoods (over 13 inches d.b.h.), and considerable young growth. Figure 1 shows the number of trees, basal area, cubic feet, and board feet by diameter- and timber-classes. Figure 2 shows in basal area per acre the present growing stock, a proposed improvement cutting of the present stand, and estimated growing stock and proposed cuts at the end of each of four successive 10-year cycles. Detailed growth studies of this timber show that the pine volume is growing at a rate of 6-7 percent compounded annually.

If 586 board feet per acre of pine are cut in 1937 to improve stand conditions, it is estimated that by 1947, i.e., at the end of a 10-year cutting cycle, the residual pine stand of 2,396 feet per acre will have grown to a volume of 4,528 board feet, or at the rate of 213 feet per acre per year.

This assumes the same rate of diameter growth by size-classes as was determined for the stand before the improvement cutting, and should give a conservative figure, since many of the poorer, less-thrifty trees were removed. In 1947 it is proposed to harvest 25 percent of the sawtimber, or 1,132 feet per acre, thus reducing the stand from 4,528 feet to 3,396 feet. Assuming the same rate of growth, by the end of the second cutting cycle, or in 1957, the stand should have increased to 5,933 feet, which represents a growth rate for the second 10-year period of 254 feet per acre per year. A cut in 1957 of 30 percent of the growing stock, or of 1,780 feet, would reduce the stand to about 4,153 feet per acre, but growth during the third cutting cycle would build it up to 6,967 feet by 1967, or at the rate of 281 feet per acre per year. Another cut of 30 percent of the growing stock in 1967 should yield 2,090 feet per acre and leave 4,877 feet of sawtimber. During the fourth cutting cycle, growth at the rate of 303 board feet per acre per year would build the sawtimber up to 7,908 feet per acre. A cut in 1977 of 30 percent of this volume would yield 2,372 feet per acre and cut the stand back to 5,536 feet per acre. Thus, during a 40-year period, it is estimated that the stand would yield 7,960 feet per acre from five cuts, although the first cut, made when the property was first put under management, is really a cut of material accumulated from growth during the years previous to management. The total growth during the 40 years is estimated as 10,514 board feet per acre, or an average of 263 board feet per acre per year. The gain per acre in the reserved growing stock from the beginning of the first cutting cycle (2,396 feet) to the beginning of the fifth cutting cycle (5,536 feet) would then be 3,140 feet.

Table 3 shows at each cutting cycle the estimated volume per acre of growing stock before and after cuts, the volume of cut, the gain in volume of the residual stand, and the total and annual volume growths.

Table 3. Estimated sawtimber[1] and cuts and growth per average acre during four 10-year cutting cycles in second-growth loblolly and shortleaf pine

Item	1937	1947	1957	1967	1977	40-year period
	Board feet (International $\frac{1}{4}$-inch kerf rule)					
Stand before cutting	2,982	4,528	5,933	6,967	7,908	--
Stand after cutting	2,396	3,396	4,153	4,877	5,536	--
Growth cut	586	1,132	1,780	2,090	2,372	7,960
Growth added to growing stock	--	1,000	757	724	659	3,140
Total growth during the period	--	2,132	2,537	2,814	3,031	10,514
Average annual growth during the period	--	213	254	281	303	263

[1] Trees over 13 inches d.b.h.

It should be emphasized that the figures in table 3 are only estimates or predictions. Although based on an existing stand of 1,000 acres of shortleaf and loblolly pine and on the present diameter growth rates of this stand, they are not based on actual measurements of growth and yields as measured at the end of a period of management. Many unforseen contingencies may arise during 40 years of forest management, but since these figures do not provide for increased growth rates under good management, it is believed that they are conservative. A further word of caution should be added, however: these figures apply only to the conditions found on the 1,000 acres referred to, and cannot safely be applied to other holdings without a careful consideration of local conditions, which may produce radically different yields and growth.

The possibilities of growth and yields from hardwood sawtimber associated with pine are not predicted because current studies of volume and value yields of hardwoods have not yet been completed. The great variety of species complicates the problem. Although hardwoods play a minor role in the loblolly-shortleaf pine-hardwoods type, hardwoods under good management can contribute to the total income, and the possibilities in this direction should be developed.

If each cut is made on a cultural basis, that is, if trees of poor form and vigor are removed, and if vigorous, clear-stemmed trees are reserved, with as large a proportion in merchantable size classes as is financially feasible, the quality and value of the growing stock will be increased continually. Figure 2 shows, for example, that in 1937 there is only a fraction of a pine tree per acre in the 22-inch class and that none are in larger classes, while in 1977 one may expect to find a few pine trees as large as 32 inches d.b.h. In 1937 the volume of pine trees in the large-sawtimber class is only 104 board feet per acre, but by 1977 it is estimated that the reserved stand will have about 2,100 board feet in this class. With larger sizes and better quality timber to select from, the average value per M board feet of stumpage cut from the stand in 1977, without any assumption of an increase in the general market prices of stumpage, may well be at least twice the present value, although full realization of such values may have to await the general recognition of log grades. Stumpage and logs are not now commonly graded in the South, but they doubtlessly will be within a few years, inasmuch as such grading is highly desirable and is now practiced in most of the other forest regions.

Assuming that the stumpage values per M board feet of cut and growth in 1937 is $4, in 1947 is $5, in 1957 is $6, in 1967 is $7, and in 1977 is $8,[6] then the values of the volumes of the cut, the growth, and that part of growth added to the growing stock (given in table 3) are as shown in table 4.

Table 4. Estimated value of sawtimber cuts and growth per average acre during four 10-year cutting cycles in second-growth loblolly and shortleaf pine

Item	1937 at $4 per M ft.	1947 at $5 per M ft.	1957 at $6 per M ft.	1967 at $7 per M ft.	1977 at $8 per M ft.	40-year period
Growth cut	$2.34	$5.66	$10.68	$14.63	$18.98	$52.29
Growth added to growing stock	-	5.00	4.54	5.07	5.27	19.88
Total growth during the period	-	10.66	15.22	19.70	24.25	69.83
Average annual growth during the period	-	1.07	1.52	1.97	2.42	1.75

From these figures it is seen that on 1,000 acres of typical second-growth pine with 2,982 board feet per acre, a light cut of 586 feet per acre, or a total of 586 M board feet for the whole property, will yield an immediate income of $2.34 per acre or a total of $2,340 if stumpage is worth $4 per M board feet. During the first 10-year cutting cycle, growth amounts to about 213 board feet per acre per year or a total of 2,132 M feet on the 1,000 acres during the 10-year period. This 2,132 M feet, valued at $10,660 if stumpage is worth $5 per M board feet, is the maximum volume that can be cut from the property without depleting the growing stock and gives the equivalent to an annual income of $1.07 per acre. Because the property is understocked, it is advisable to cut only 25 percent of the sawtimber, or 1,132 board feet per acre, and to add 1,000 board feet to the growing stock. The value of the total cut on the property is then $5,660, representing an annual income of 57¢ per acre, and the value added to the growing stock is $5,000 or 50¢ per acre per year. It should be pointed out that this addition to the growing stock can be cut at any time, if necessary. If left uncut during the next 10 years not only will it increase in volume at a rate of about 6 percent compounded annually, but it also increases in quality so that it is worth about $1.00 more per M board feet. Table 4 indicates that the value per M board feet of the annual growth per acre increases with each successive cutting cycle from $1.07 to $1.52, then to $1.97, and finally to $2.42. The total values of the proposed cuts for the 1,000 acres also increase as follows: 1st cut of about 20 percent of the growing stock - $2,340; 2nd cut of 25 percent of the growing stock - $5,660; 3rd, 4th, and 5th cuts each 30 percent of the growing stock - $10,680, $14,630, and $18,980, respectively.

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[6] Stumpage values have been increased for each cutting cycle of 10 years because under good management the quality and value of the timber cut continually increase. The standard stumpage price for average second-growth loblolly and shortleaf pine on Forest Service sales in 1936 was $7 per M board feet; since considerably higher prices were received on some sales, the values used evidently are conservative.

In addition to the income from stumpage for pine sawtimber, some income should be derived from pine pulpwood stumpage and from hardwood-sawlog and fuelwood stumpage. Studies made by the Southern Forest Experiment Station indicate that the cubic-foot volume of pulpwood that can be cut from tops, thinnings, and improvement cuttings, equals one-half to the full amount of the total cubic-foot volume of sawtimber cut. These studies show that when the improvement cutting of 586 feet of pine sawtimber is made, approximately 1 cord of pulpwood with a stumpage value of 75¢ can be cut from tops of felled sawtimber trees and from other trees removed in stand improvement work that are unmerchantable for sawlogs. At the end of the first 10-year cutting cycle, it is estimated that another 1½ cords with a stumpage value of $1.13 can be cut.

Merchantability of hardwoods associated with pine is more uncertain. Studies of improvement cuttings for chemical wood indicate that a yield of a cord per acre, with a stumpage value of 50¢, can be removed at the beginning of the first cutting cycle, and that a total income of $1.50 for hardwood sawtimber and cordwood stumpage can be obtained at the end of the first 10-year cycle.

The total income for the 1,000-acre forest from the first cutting in 1937, which is more of an improvement cutting than a harvest cutting, is estimated as follows:

586 board feet of pine sawtimber at $4 per M board feet = $2.34 per acre x 1,000 acres =	$2,340
1 cord of pine pulpwood per acre at 75¢ per cord x 1,000 acres =	750
1 cord of hardwood fuelwood per acre at 50¢ per cord x 1,000 acres =	500
Total income, 1937 =	$3,590

The total income at the end of the first cutting cycle, or in 1947, is estimated as follows:

1,132 board feet of pine sawtimber at $5 per M board feet = $5.66 per acre x 1,000 acres =	$5,660
1½ cords of pine pulpwood per acre at 75¢ per cord = $1.13 per acre x 1,000 acres =	1,130
Hardwood sawtimber and fuelwood at $1.50 per acre x 1,000 acres =	1,500
Total income, 1947 =	$8,290
Value of growth added to growing stock =	5,000
Total value of cut and growth added to growing stock =	$13,290

If the total income per acre for the 10-year period is $8.29, the average annual income per acre is 83¢. When one considers the value of the growth which was not cut but was added to growing stock, the average annual income per acre becomes $1.33.

At the end of four cutting cycles, or in 1977, it is estimated that the income will be as follows:

2,372 board feet of pine sawtimber at $8 per M board feet = $18.98 per acre x 1,000 acres =	$18,980
3 cords of pine pulpwood per acre at $1 per cord = $3 per acre x 1,000 acres =	3,000
Hardwood sawtimber and fuelwood at $3 per acre x 1,000 acres =	3,000
Total income, 1977 =	$24,980
Value of growth added to growing stock =	5,270
Total value of cut and growth added to growing stock =	$30,250

The average annual income per acre for the fourth 10-year period therefore is $2.50, and when the value of the growth added to the growing stock is also considered, the average annual income per acre becomes $3.02.

Again it should be pointed out that all these figures are theoretical and have not been obtained after long years of management, but it should also be stated that second-growth stands with better stocking than that estimated for this stand in 1977 (viz., 5,536 board feet per acre) can readily be found on limited areas, having grown to their present volume in spite of periodic fires and without any management or cultural care. In other words, owners starting their forest management with better stocked stands can expect better returns than those predicted herein, while those owners beginning management with poorer stands and less favorable growing conditions must be content with smaller yields and less income.

The annual costs per acre for forest management in this forest region in 1937 are about as follows:-

Taxes	$0.15
Fire protection	.03
Administrative costs	.03
Technical services of forester and assistants	.04
Total	$0.25

With a gross annual income of about 83¢ per acre during the first cutting cycle, deduction of this total cost of 25¢ leaves 58¢ as the net annual income per acre. On 1,000 acres this totals only $580 per year in cash, but stumpage valued at $500 is also added each year to the growing stock. This stumpage, which grows in volume at a rate equal to more than 6 percent compounded annually and which is estimated to increase in value during a 10-year period about $1 per M board feet, can be liquidated at any time that the owner finds it necessary.

As the returns from forest management increase and growing-stock values are built up, some increase in the annual expenses per acre may be expected, but where rather intensive forestry is practiced and a heavy growing stock is maintained, the following is considered a reasonable statement of cost:

Taxes	$0.25
Fire protection	.08
Administrative costs	.05
Technical services of forester and assistants	.07
Total	$0.45

It will be noted, however, that this increase in costs is not proportionate to the increase in returns under management. With a gross annual income per acre in 1977 of $2.50 and a total cost of 45¢ per acre, the net income is $2.05 per acre per year, and in addition growth valued at 53¢ per acre is added each year to the growing stock. Thus, as the yield improves, the margin of net earnings is materially increased.

This paper, which has reviewed very briefly a subject that would require several textbooks to develop, has necessarily left entirely untouched numerous subsidiary matters; but in conclusion it should be emphasized that the present prospects of profitable management of shortleaf and loblolly pine for sustained yield are bright. In fact, a number of lumber companies and other forest owners in the region where these forest types predominate have definitely adopted the practices recommended in this paper and are finding them more profitable than former cutting methods which removed practically all marketable material. As operators familiarize themselves with the principles of good forest management, undoubtedly they will become progressively convinced of the fact that sustained-yield forest management pays.

SUMMARY

Satisfactory commercial forest management must not only produce continuous yields but it must also raise them to, and sustain them on, an adequate level. A prerequisite for such sustained-yield management in the shortleaf-loblolly pine-hardwood type of forest is dependable protection from fire. If the average area burned per year is limited to less than 1 percent of the total forest area protected, adequate reproduction of pine will generally follow all types of partial cutting, except infrequent, very light or very heavy cuts.

Where pines are reproducing satisfactorily, as they seem to be over most of the shortleaf-loblolly pine region, pine seedlings require no detailed attention in cruising timber. Hence the volume and growth of the merchantable and premerchantable portions of the sawtimber growing stock are generally the only ones that require preliminary detailed determination by size-classes. These preliminary cruises, in order to avoid unwarranted expense, should ascertain total timber stocks and average rates of growth only for the forest as a whole, or for large "working circles" or blocks but not for any of the smaller subdivisions of the property such as individual logging units or compartments, which can be cruised more economically later. Accordingly, these preliminary systematic timber cruises should not attempt to map or locate timber, but should merely try to determine the timber-growing capacity. Where conditions are fairly uniform on tracts of 10,000 acres or larger, the blanket determination of merchantable timber stocks and rates of growth can often be accomplished very economically, as sample plots requiring actual measurements of trees do not total more than 1 percent of the forest area.

The practical purpose of the non-intensive, initial timber cruise is to provide the information essential for a working plan to regulate the current removal of timber, so that the total cut will not exceed the growth. Preliminary forecasts of the growth of merchantable timber volumes are best obtained, after due allowance is made for loss from natural causes, by contrasting present stocks, class by class, with those on the ground 5 or 10 years previously, and by assuming that growth for the next several years will closely approximate the past growth as measured. Such forecasts of periodic growth form the basis for the necessary limitation of the total volume of timber to be cut from the forest during the next period; and to attain a material increase in future yields from forests not up to capacity production, a certain percentage of the growth (perhaps 20 percent) should be reserved if possible by this limitation.

The forest should be divided into compartments of convenient size (500 to 2,500 acres each) to facilitate protection, administration, and management. Roads, fire lines, open fields, streams, etc., can be used for compartment boundaries. Also a history of all cultural operations and yields should be kept for each compartment so that valuable detailed data on timber stands and growth—data not obtained in the preliminary cruise—will gradually accumulate. Pending the acquisition of the more reliable and realistic information resulting from actual experience in forest management, the effort and expense required to prepare a lengthy, rigid, and detailed plan of forest regulation cannot be justified. If the preliminary written plan of management ventures beyond a mere statement of policy, the detailed specifications of such a plan may need to be revised frequently. The general policy and purpose of management, however, must be perpetuated for best results over a long period.

While economic means of regulating the cut require early attention, the most immediately available benefits in organizing a forest for sustained yield are those which result from better silviculture. Fortunately, marked improvement in cultural operations are now feasible over wide areas, largely because auto-trucks, tractors, roads, and other transportation facilities have increased the accessibility of timber. Wherever conditions permit, the growing stock should be enhanced in value (both volume and quality) by cutting frequently and lightly in all accessible stands, constantly removing inferior trees and reserving the better ones. The less promising trees should be eliminated gradually from all merchantable size-classes whenever for any reason they become incapable of further satisfactory increases in volume, quality, or value (i.e., at financial maturity). Cuttings should be made first in those compartments where salvage appears most urgent because of the prevalence of over-maturity, insect depredations, disease, windfall, or fire damage. Early harvesting is also indicated for certain compartments in urgent need of thinning or other improvement cuttings.

Silvicultural marking of all timber for cutting is an art which is vital in the practice of forestry. Based in part on the technology of forest products and tree growth, it nevertheless rests very largely on the judgment of the marker, who should be an experienced man, working under the supervision of a competent forester. Marking crews not only should designate each individual tree to be cut but also should make a complete tally by diameter-classes of all merchantable trees segregated as to whether they are to be cut or left. This procedure not only provides a convenient means of keeping currently informed as to the amount of the cut, but it also produces an accurate but inexpensive inventory of timber resources by compartments. The continued repetition of such complete inventories at each regular cutting will eventuall supply the most accurate bases possible for limiting the cut to the growth capacity, because in its simplest terms the net growth of timber on any compartment is the difference between the volumes of merchantable timber at the beginning and end of a cutting cycle.

The crucial question in the commercial application of any constructive program—"Will it pay?"—must be answered separately for each forest, but some outstanding financial aspects bearing on the system of light and frequent selective cuts should be mentioned. After the initial improvement cuttings have removed low-value trees (including numerous small ones), the average size of logs in subsequent cuts should be larger, and for larger trees and logs the cost of logging and milling is appreciably less, while the selling price per M board feet of the lumber produced is greater.

Rapidly developing markets for southern pulpwood offer increased opportunities to promote good forestry practices. These new markets assist partly by permitting more complete utilization of sawtimber, but more especially by making extensive thinning and improvement cutting profitable in smaller and younger timber. Obviously a skillful integration of utilization offers the best possibilities for profit, as the stumpage values of trees which are suitable for lumber, posts, poles, or piles is often four to six times as much per cubic foot as the value of the same timber used for pulp or chemical wood. The high value of certain trees which can meet the exacting requirements of special uses should not be sacrificed, as it commonly is, by marketing this material indiscriminately mingled with logs yielding only low-value products.

Although conditions vary enormously in the shortleaf-loblolly pine-hardwood type of forest, a net annual income of $1 per acre can be expected from reasonably good management of typical second-growth stands (averaging about 3,000 board feet per acre) under existing markets; and it is believed that after several cutting cycles under sustained-yield management, this net income can be increased materially.

OCCASIONAL PAPER NO. 71 DECEMBER 4, 1937
(Reissue, Feb. 12, 194)

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

PULPWOOD PRODUCTION STUDIES IN SHORTLEAF-LOBLOLLY PINE STANDS

By

R. R. Reynolds, Associate Forest Economist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

Note: Assistance in the duplication of this paper was furnished by the personnel of Work Projects Administration official project 165-2-64-102.

PULPWOOD PRODUCTION STUDIES IN SHORTLEAF-LOBLOLLY PINE STANDS[1]

By

R. R. Reynolds, Associate Forest Economist
Southern Forest Experiment Station

In 1934 the Crossett Lumber Company gave the Federal Government 1,680 acres of second-growth pine and hardwood timberland 7 miles south of Crossett, Arkansas. The purpose of this gift was to establish a proving ground not only for testing the possible costs of, and returns from, various kinds of sawlog, pulpwood, and post and pile cuttings, but also to provide an area on which to determine the costs of handling timber as a crop and the returns therefrom.

Shortly after receiving the gift, the Southern Forest Experiment Station began a series of experiments on timber growing. Among these experiments was one in thinning old-field and natural second-growth pine stands for pulpwood, some of the interesting results from which I shall discuss.

In order to provide for future cuts, it is necessary to leave a good stand each time an area is cut over. We do not know, however, the exact number of trees that should be left to obtain the largest possible returns from our timberland. Should we leave 50, 100, 200, or even more trees per acre? Will greater returns be obtained by leaving the larger trees instead of the smaller ones at the time of cutting? What sized trees will yield the greatest profits if removed, and what sized trees will show the greatest increase in value if left at the time of cutting? The purpose of our experimental work is to answer some of these questions, and for this purpose we have established the following 1-acre test plots:

Test #1. We left about 200 of the straightest, cleanest, and best trees per acre spaced as evenly as possible (average spacing 15 x 15 feet). All straight trees under 6 inches d.b.h. not interfering with the crop trees were also left. The volume of pulpwood in the reserved trees was 24.4 cords. The cut removed 239 trees, from which 12.2 cords of pulpwood was produced.

Test #2. We left about 100 of the straightest, cleanest, and best trees per acre (average spacing 21 x 21 feet). Here also were left all straight and promising trees under 6 inches d.b.h. that did not interfere with crop trees. On this area we left 14.5 cords of wood per acre in reserved trees and cut 291 trees or 24.4 cords.

Test #3. We left about 70 of the straightest, cleanest, and best trees per acre (average spacing 25 x 25 feet) and also the straight and clean trees under 6 inches d.b.h. The amount of material left per acre was 13.5 cords, while we cut 240 trees or 27.8 cords per acre.

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[1] Presented before Group #4 of the Southern Pine Pulpwood Industry at Crossett, Arkansas, November 18, 1937.

Test #4. We left about 40 of the best trees per acre (average spacing 33 x 33 feet), plus the straight and clean trees under 6 inches d.b.h. On this area we left 8.4 cords per acre, and cut 285 trees or 30.4 cords per acre.

Test #5. We left all trees up to (and including) 7.5 inches d.b.h. with the exception of leaning trees and trees with rot. We also left 1 good seed tree every 50 feet. On one plot cut under this method 201 trees were left per acre and on another 67 trees per acre, amounting to 13.3 and 6.7 cords, respectively. On the first plot we cut 24.6 cords per acre and on the second 45 cords.

Although it will be some time before we know exactly the type of cutting that will yield the greatest yearly income, present results indicate that for timber stands averaging up to 10 inches in diameter, a type of cutting in which between 100 and 200 of the best trees are left per acre will prove most profitable. Unless such timber is on very poor soil, one can reasonably expect such a stand to grow each year an equivalent of 1 cord per acre. This means that it will be possible to go back to the same area and cut the equivalent of 5 cords of pulpwood every 5 years at least until the trees reach saw-timber size. Many of the reserved trees will develop into high-quality trees, which if cut into sawlogs and piling will be worth from 3 to 10 times the value of such trees when cut for pulpwood. It is hardly necessary to add that potential saw-timber and piling trees should not be cut for pulpwood if the greatest profit from growing timber is the aim of our timber farming.

It will be noted that our pulpwood-cutting Test #5 follows almost exactly the cutting rules of the American Pulpwood Association, under which pulpwood producers are now working. The only difference is that we left a good seed tree every 50 feet in order to be sure of obtaining reproduction in case most of the present stand should be destroyed by fire or wind. Under the Association cutting rules, in some cases a very good stand will be left, but in other cases practically everything will be cut. In spite of heavy cutting in the shortleaf-loblolly pine type, most areas will undoubtedly reseed to trees and eventually another crop of timber will be produced. The resulting annual income per acre, however, is likely to be low, owing to the fact that it will be many years before the trees become of merchantable size. The costs per acre, on the other hand, will be the same as for areas containing high-quality growing stock.

The pulp mills in this country will require many years to depreciate their investments, and throughout all of these years they will need at least as much wood as is needed this year. The contractors producing pulpwood for these mills also will be in business during these years and will need timber to cut. It is the wish and aim of each timberland owner to make as much money as possible each year from his timberlands. To all who are interested in growing and producing pulpwood let us urge you, for your own good, to seriously consider the Association rules only as a minimum or as a starting point in determining the kind or amount of timber you should leave at the time of each cut. To abide strictly by the rules means that in some cases you will not net enough from the growth on the remaining trees to pay for the taxes, whereas if you leave a good stand at the time of each cut, there is no evident reason why you cannot net at least $1.00 per acre per year from the growth. You will all agree that you can't chop out two out of every three rows of cotton and still hope to get much of a yield per acre. Neither can you cut out two-thirds of your tree crop and hope to get much in the way of returns from growth. Those of you who expect to be in the pulpwood production business for a long time in the future will also agree, it is hoped, that pulpwood stands close at home, or close to the pulpmill, are cheaper to cut and haul than stands 30 to 50 miles distant.

In all of these cuttings we have kept records of the costs of cutting pulpwood from trees of each size class in order to determine whether some trees were costing more to cut than the value of the products obtained. These records, which we have on some 4,000 trees, indicate the number of minutes it takes to cut a tree into pulpwood and the corresponding pulpwood volume in the tree. From this information we have determined the cost of cutting a cord of wood (including felling, bucking, saw-filing, oil, and wedges) as follows:

Tree diameter (at 4½ ft. from the ground)	Cost of cutting per cord
4-5.9 inches	$1.40
6-8.9 inches	.90
9-11.9 inches	.72
12 inches and above	.76
Average of all trees cut	$0.80

Thus, on the basis of the number of minutes per cord, the cost of cutting trees 4 to 5.9 inches d.b.h. is almost exactly double the cost of cutting a cord from trees 9 inches d.b.h. and above. Since the sale value of the pulpwood was $2 per cord, a margin between sale value and cost of production remained for stumpage and profit in all size classes, but this margin was greatest in the 9-11.9-inch class and was least in the 4-5.9-inch class; for the total volume cut it averaged $1.20 per cord.

We know, of course, that many of you are having your cutting done by contract at so much per cord, regardless of the size of trees, so that it actually does not cost twice as much to cut trees 4-6 inches d.b.h. as to cut trees over 9 inches d.b.h. It does, nevertheless, cost considerably more to cut small timber even by contract, because it is necessary to have additional saw crews to cut the same amount of wood; and this means additional cost for more saws, more saw-filing, more wedges, and more oil. Also the hauling cost is somewhat greater for small wood than for large, and it costs considerably more to convert a cord of small wood into chips at the plant than it does to convert a cord of large wood. One should cut small trees into pulpwood only when clearing the land for farming or if the trees are badly suppressed, rotten, or crooked.

Not only does it cost more per cord to produce pulpwood from smaller trees than from larger ones, but the value per tree is very much less for the smaller trees. On the average, to make a cord of wood it takes about 106 four-inch trees, 50 five-inch trees, 27 six-inch trees, 16 seven-inch trees, 11 eight-inch trees, or 4 twelve-inch trees. With pulpwood stumpage at 75¢ per cord, 4-inch trees are worth about 3/4¢ each, 5-inch trees about 1-1/2¢ each, 6-inch trees about 2-3/4¢, 7-inch trees about 4-1/2¢, 8-inch trees about 7¢, 9-inch trees 9-1/2¢, and 12-inch trees about 20¢ each. (See table 1 for values of trees 4-15 inches d.b.h.) Thus 8-inch trees have a stumpage value 10 times that of 4-inch trees, while the cost of production is only half as much per cord.

On the other hand, we have found that small trees, with reasonably good crowns and spacing, are increasing in value at an extremely rapid rate. For instance, in growing 1 inch in diameter a 4-inch tree increases 114 percent in value, a 5-inch tree 80 percent, a 6-inch tree 70 percent, and a 7-inch tree 50 percent. Surely most of us, as well as other timberland owners, could be interested in making 70 or 80 percent on our money in about 3 years.

Table 1.—Volumes and pulpwood stumpage values of shortleaf and loblolly pine by tree sizes on the Crossett Experimental Forest

Diameter at breast height inches	Volume per tree	Trees per cord	Pulpwood value per tree at 75¢ per cord stumpage	Value of 1 inch of growth in diameter	Increase in value for 1 inch increase in diameter
	Cubic feet	Number	Cents	Cents	Percent
4	0.8	106.2	0.7	0.8	114
5	1.7	50.0	1.5	1.2	80
6	3.1	27.4	2.7	1.9	70
7	5.2	16.3	4.6	2.3	50
8	7.8	10.9	6.9	2.5	36
9	10.7	7.9	9.4	3.0	32
10	14.1	6.0	12.4	3.5	28
11	18.0	4.7	15.9	3.9	25
12	22.4	3.8	19.8	4.1	21
13	27.1	3.1	23.9	4.4	18
14	32.1	2.6	28.3	4.7	17
15	37.4	2.3	33.0	5.1	15

Quite often we hear the statement: "I can't afford to leave small trees because I have purchased all the pulpwood on this forty, and if I don't cut it all I will lose money." In a very few cases this may be true. There is one way, however, to buy pulpwood so that you may be absolutely certain to pay for only the amount that you cut: that is to buy on the cord basis. Such a method is absolutely fair to both buyer and seller and you do not have to worry as to whether your estimate of the amount of timber is correct. In fact you do not have to make an estimate. The only reason for buying timber on the 20- or 40-acre basis is because you think you can fool the seller on the amount of pulpwood present, and the man who owns the tract of timber thinks he can fool you. It's like buying a "grab-bag" package at a charity sale; you don't know what you've got until you unwrap it. But if you purchase by the cord both you and the landowner will know that you will get what you pay for. Furthermore, both of you can afford to leave a good stand at the time of cutting.

I have just one more thought to leave with you. I know that many contractors require the cutters to "pen" their wood, apparently as a means of "paying off." Of course there is nothing very wrong with this practice, especially if cutters are plentiful and you do not care how much wood each crew cuts per day. If labor is scarce, however, or if you are interested in having each crew cut as much as possible each day, then you should seriously consider changing this practice. We have tried both penning and not penning, and we find that loading costs when picking the wood off the ground differ very little if at all from those when loading the wood from pens. We have also found that it requires a fifth to a fourth of a crew's time to do the penning. Our crews would rather cut an extra 50 sticks of wood per day than spend that time in penning. This is, therefore, a way to obtain cheaper wood. In place of paying for the cutting on the basis of number of pens, we pay so much per 100 sticks and find that this method is entirely satisfactory. If the crews are not honest in their count or can't count, we assign each crew to a definite area and pay off on the number of cords that are hauled from that area. This also has proved to be a very satisfactory method.

In conclusion, let me repeat that our studies show that there are possibilities of large returns from timber growing, either as pulpwood alone or for pulpwood in combination with logs and poles and piling. In order to obtain these returns, however, it is necessary that we use the same common sense and good management in harvesting the crops of timber that we use in converting the wood into paper or boards. And I cordially invite all of you to visit the Crossett Experimental Forest and to see the results of these studies on the costs and returns of growing timber as a crop.

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

RUST CANKER DISEASES OF SOUTHERN PINES

by

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Division of Forest Pathology, Bureau of Plant Industry,
in cooperation with the Southern Forest Experiment Station,
Forest Service, U. S. Department of Agriculture

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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The four principal species of southern pines—longleaf pine (Pinus palustris Mill.), slash pine (P. caribaea Morel.), loblolly pine (P. taeda L.), and shortleaf pine (P. echinata Mill.)—are subject to infection by two native rust fungi, Cronartium cerebrum Hedgc. and Long and C. fusiforme Hedgc. and Hunt. These fungi, which are not known to spread directly from pine to pine, require oaks as an alternate host to complete their life cycles. The galls or cankers caused by these fungi are easily seen on the trunks or limbs of pine seedlings, saplings, and larger trees. The galls or cankers caused by C. cerebrum are round or globelike, while those caused by C. fusiforme are spindle shaped, as illustrated by photograph B.

In late winter and early spring in the Gulf States, these cankers fruit, producing on the surface numerous orange-colored aeciospores, which may be carried by air currents to the young foliage of the several species of scrub oaks common in the region. After the oak leaves have become infected by the aeciospores from the pine, it is possible to see with the unaided eye the fungous structures that appear on the lower side. At first, small round uredia develop, which eject orange-colored uredospores that serve to increase the amount of infection in the oak foliage. Later, in the spring and early summer, from the spots where uredia were produced arise brown hairlike structures known as telia (photograph C), which bear teliospores that germinate and produce sporidia. These sporidia may be carried by air currents for 1,000 feet or more to the growing shoots of pines where they may cause in the pine tissues new infections which later result in galls or cankers. The active period of propagation of these rusts is from early spring to early summer; after that period it is thought that there is little or no increase in pine infection.

Several oak species are known to be infected by these rusts, but further studies are needed to determine the species most susceptible in the Southern States. In this paper, however, the term "scrub oak" is used to cover the oaks often known as "blackjack" or "bluejack" and which are comcommonly found as low bushes or scrubby trees on cut-over pine lands in the Southern States. Quercus marilandica Muench., Q. rubra L., and Q. cinerea Michaux, are common species of this type of oak.

Of the southern pines, longleaf pine is commonly considered the most resistant, and only a few instances of severe rust infection have been noticed in natural reproduction of that species. Shortleaf pine was not severely infected in the areas visited by the writer, but it is reported that this species is quite susceptible to rust fungi in some areas in the South. Both slash and loblolly pines are susceptible to the disease in the nursery, in plantations, and in stands of natural reproduction. The increasing interest in the reforestation of cut-over lands, therefore, as well as the growing interest among foresters and woodsmen in rust diseases, have resulted in these studies and observations, which indicate the increasing importance of these native diseases, formerly considered of only minor significance in the Gulf States.

Infection in Nurseries

Early in August 1937, abnormal swellings were noticed on the stems of slash pine seedlings in two nurseries in southern Mississippi. By means of microscopic examinations of sections cut from these swellings, it was possible to demonstrate that a rust fungus was present therein. An examination of scrub oak foliage in the vicinity of one nursery made soon after, showed that oak infection was common; Quercus marilandica was the species most severely infected, with Q. rubra ranking second in susceptibility.

In September a survey was made of 10 nurseries growing pine seedlings, in an effort to learn the extent and severity of rust infection in Southern nurseries. Examinations were made in at least 10 different places in each nursery in order to obtain a fair picture of the average amount of disease present; and 100 seedlings were closely inspected at each place, some from the outer part of the seedbed and others from near the center. At the same time notes were taken on the amount of native pine and scrub oak infection near the nursery. From the summary of the data taken on this survey, as given in table 1, it will be seen that numerous pine seedlings are becoming infected in the seedbeds. Both fusiform and cerebroid cankers were found on the seedlings examined, and all infections were on the stems of the diseased plants, as illustrated in photograph A.

Infection in Young Plantations

Seedlings in young pine plantations may become infected from two distinct sources. The first is planting stock infected in the nursery. Several years are required for cankers present on the pine seedlings to develop and produce spores that will increase the amount of rust infection, and since cankers resulting from nursery infection are near the ground line and not ordinarily noticed, it will probably be at least 4 or 5 years before the damage becomes evident. By this time many trees with stem infections will be dead, and cankers resulting from infections that have occurred after planting will become large enough to be noticed easily.

Scattered seedlings with cankers undoubtedly resulting from nursery infection have been found in plantations in Louisiana, Mississippi, and Georgia. Several of these plants were dead or dying; others, alive and apparently vigorous, will probably survive long enough to permit spore production. Scrub oaks were growing in or near all of these plantations, and it is probably only a matter of time before cankers become common. Where 3 percent of the planting stock is diseased when placed in the field, 30 infected trees will be found in every 1,000 seedlings, which is the approximate number planted per acre. If only 5 percent of these survive long enough to produce spores and if scrub oaks are abundant in the vicinity, the stage is set for the production of inoculum sufficient to result in a few years in a severe outbreak of the rust on the trees that were healthy when planted.

The second source of infection is formed by diseased native pines and scrub oaks growing near a plantation. Such trees were quite common in most

Table 1. Prevalence of rust infection on pines in Southern nurseries

Locality and operating agency	Pine species examined	Approximate no. examined	Percent infected	Name and condition of nearby scrub oaks	Name and condition of nearby pines
Woodworth, La.; State Dept. of Conservation	Slash Loblolly	700 300	0 0	No infected oaks noted.	Infected loblolly half a mile from nursery.
Sibley, La.; U.S. Soil Conservation Service	Slash Loblolly	200 900	0 0	No infected oaks noted.	No infected pines noted.
Pollock, La.; U.S. Forest Service	Slash Loblolly	1,100 100	(1 seedling)[1]	Infected *Q. rubra* on all sides of nursery.	Several infected loblolly, four infected longleaf near nursery.
Brooklyn, Miss.; U.S. Forest Service	Slash	3,600	4.5 (0-13)[2]	Numerous infected *Q. marilandica* and some infected *Q. rubra* near.	Numerous infected loblolly nearby.
Wiggins, Miss.; State Forest and Park Service	Slash	1,000	5.7 (1-12)	Numerous infected *Q. marilandica* near.	Numerous infected slash and loblolly near.
Livingston, Ala.; State Commission of Forestry	Slash Loblolly	500 600	3.8 (2-5) 3.1 (1-6)	Numerous infected *Q. marilandica* nearby.	Nursery surrounded by slash and loblolly; many are infected.
Americus, Ga.; U.S. Soil Conservation Service	Slash Loblolly	1,200 1,500	2.0 (0-4) 3.8 (0-8)	Infected *Q. marilandica* within a few rods of seedbeds.	Infected slash a few rods from seedbeds.
Albany, Ga.; State Department of Natural Resources	Slash	1,300	0.8 (0-3)	Infected scrub oaks (species?) about 1,000 feet from seedbeds.	Infected slash a few rods from seedbeds.
Milton, Fla.; U.S. Farm Security Administration	Slash	1,000	2.8 (0-5)	Infected scrub oaks (species?) nearby.	Infected slash and loblolly nearby.
Olustee, Fla.; State Forest and Park Service	Slash	1,000	0	No infected oaks.	No infected pines.

[1] On December 8, 1937, a small percentage of infected seedlings was found.
[2] Range in percent of infection.

of the planting areas visited in the region and the resulting infections are quite evident (photograph D) in the early years of the plantations, where cankers resulting from field infection and high enough to be easily noticed are found upon the trunk and branches of trees only a few years old. In one 3-year-old slash pine plantation in Mississippi, 13 plants out of 104 in a study plot were infected, and 9 of these are certain to die in a few years. In another slash pine plot in its second growing season, 9 out of 53 trees were infected, all 9 of which will die in a few years. All cankers in these plots are the result of field infections; in both instances oaks were numerous in or near the plantation, and infected native pine trees were growing close by.

Infection in Natural Stands

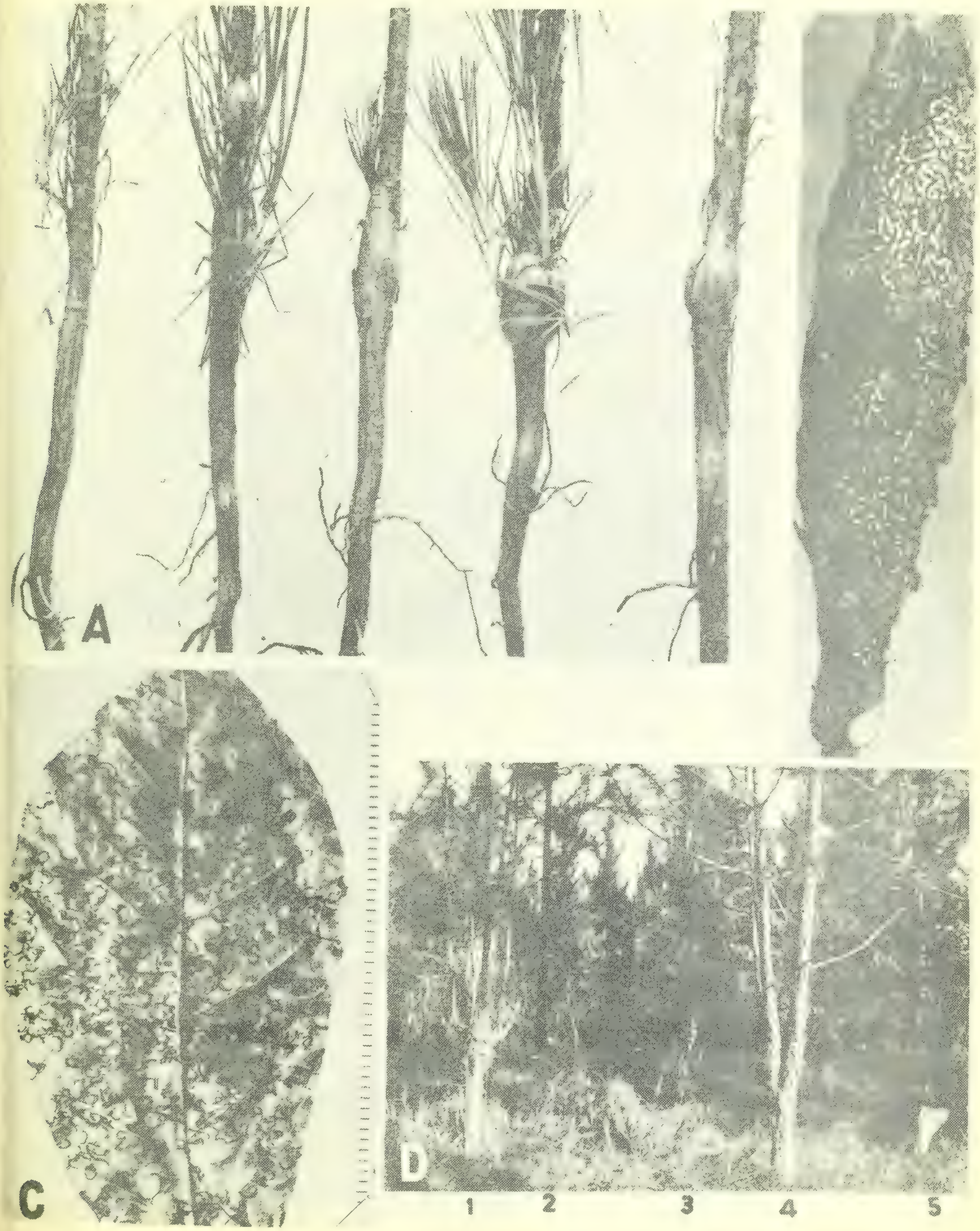
Stands of natural reproduction, in areas where fire control has allowed slash and loblolly pine seedlings to grow along with scrub oaks, are frequently found to be badly damaged by this disease. In low, swampy country where the oaks are unable to grow, the pine seedlings are free from disease, but on the ridges of higher ground where oaks are growing, the amount of disease increases.

Data on the amount of infection in several plots established for the study of the rust in southern Mississippi and on seedlings and saplings in natural stands in the vicinity of Bogalusa, La., are presented in table 2. All of these plots were located in areas where rust infection was unusually heavy and diseased scrub oaks numerous.

Table 2. Rust infection in young natural pine stands

Pine species	Location	No. examined	Age	Height	Trees diseased	Trees with stem cankers
			Years	Feet	Percent	Percent
Slash	Miss.	73	10	10 - 15	61.6	43.8
Slash	"	183	2	1/2 - 1	10.3	10.3
Loblolly	"	46	12 - 16	23 - 39	65.2	37.0
Loblolly	"	132	12 - 16	20 - 40	65.1	28.0
Slash	La.	64	-	2 - 6	20.3	7.8
Slash	"	73	-	3 - 10	24.6	17.8
Slash	"	200	-	15 - 25	4.0	0.5
Loblolly	"	71	-	10 - 20	80.2	29.6
Loblolly, slash, and shortleaf	"	400 (approx.)	-	2 - 20	6.5	0.0

A . Rust cankers on stems of 1 - 0 slash pine nursery stock. B. Typical mature fusiform gall with aecia showing on surface. C. Telia on Quercus imbricaria. This unusually heavy infection is the result of inoculation. D. Stem and branch cankers on 7-year-old slash pines in plantation in southeastern Louisiana. Persistence of the infected lateral branches and proliferation of branches are characteristic symptoms of rust infections. (B and C photographed by G. G. Hedgcock.)



The ultimate effect of these cankers upon stands of natural reproduction and plantations will depend upon a number of factors such as the age of the stand, the number of fruiting cankers, the number and species of scrub oaks present, and the density of the stand. Observations and examinations show that many diseased trees will probably die before they reach commercial maturity or will break over where the cankers occur. This is especially true if the infection takes place when the tree is young. The death of infected trees may tend to thin out a dense stand, with little harm or even with benefit, but on the other hand so many desirable trees may be lost that the stand will be greatly reduced in value. This loss will be especially important where pulpwood and other intermediate forest products are to be taken from a stand of timber, and for the study of problems of this nature plots have been established both in plantations and in areas of natural reproduction.

Effect of Current Forest Management Practices on Infection

For many years, both before and after removal of the virgin timber, fires burned over longleaf pine lands. During the last 13 years, since the Federal Government has cooperated with timberland owners and with the States, mainly as a result of the enactment of the Clarke-McNary Law, the fire problem on thousands of acres in the commercial longleaf pine region is being met successfully.

It is a matter of common observation that the commercial range of longleaf pine has been reduced by the other species of pines, particularly loblolly and slash. Without discussing all of the reasons for this change in forest type, it is believed that the exclusion of fire favors the regeneration of loblolly and slash pines at the expense of longleaf, and that the partial replacement of longleaf by slash pine in the naval-stores region of the United States is largely a result of the exclusion of forest fires from much of this territory during the last decade. Also artificial reforestation of denuded or understocked longleaf pineland has advanced rapidly, owing to a growing appreciation of the fact that the Gulf region is particularly favored by environmental and economic conditions for profitable timber growing; and the increasing popularity of slash pine for this reforestation has resulted in its use for planting beyond its natural range and on typical longleaf sites.

As a result, therefore, of artificial regeneration and the exclusion of fire on areas of natural reproduction, many areas that once carried commercial stands of longleaf pine are now covered with young forests of loblolly or slash. Since the two native rust fungi, Cronartium cerebrum and C. fusiforme, are normally endemic on loblolly and slash pines over most of the range of longleaf, with the extension of stands of rust-susceptible pines to areas of denuded or understocked longleaf land, where numerous scrub oaks were growing, conditions were made almost ideal for rust epidemics.

As each series of rust cankers matures and begins to produce spores, the number of infected oaks is increased, which results in a still greater amount of pine infection in an ever-widening circle. Many stands of slash and loblolly pine that became established soon after an area was cut over have little rust infection today, but younger stands are much more severely diseased; and the amount of disease present is increasing from year to year, as is shown by the numerous cankers that have developed in the past few years on the young seedlings and in the crowns of older trees formerly free from disease.

There are several plantations of slash and loblolly which are now old enough to illustrate the rapid increase in rust infection in the last few years. One such plantation established on cut-over pine land in 1925-26 showed a low percent of infection in the first 8 years of its history, during which time only 3 to 4 percent of the trees became infected. Three years later, however, a brief survey in the same area showed that among the 305 trees (of both species) examined, 37 percent were infected, while 10 percent had trunk infections which may cause them to break over and be lost. It is quite evident that most of the cankers now present in this stand are only a few years old and have not yet produced spores. Many of these new infections in the crowns are on the stem or on branches a short distance from the trunk.

Infection is even more severe in several slash plantations established near the older ones in 1930-31. A survey made in March 1937 in one plantation showed that 35 percent of the trees were infected and that 17 percent had cankers which would render the trees worthless in a few years. A study plot containing 75 trees was established in August of the same year, and in this plot 56 percent of the trees were infected and 23 percent so badly diseased that they are worthless. A survey made in October in another plantation of approximately the same age revealed that here 40 percent of the trees are now infected, while 25 percent are worthless because of cankers on the trunk.

In both the older and younger plantations, the fact that most of the cankers were young and had not yet fruited indicates that the number of infections is increasing rapidly. It seems probable that the higher percentage of disease in the younger plantations is largely due to the fact that the amount of oak infection has been heavier during the life of the plantation than it was in the early years of the older plantations, which in turn is probably due to the increasing number of fruiting cankers on the older pines. There is some evidence that nursery infection is responsible for some of the older cankers in the stand, and it is also probable that some of these older cankers are the result of spores produced by cankers on trees left after the area was cut over. It seems quite possible, therefore, that this rapid increase in the number of cankers and severe injury to the stand will be repeated in other young pine stands where scrub oaks are present near diseased pines.

In several of the plots established for the study of the rust canker disease, the trees, which are at least 7 years old, have cankers of several ages. Because it is very difficult to determine the age of these cankers, the 320 cankers measured in these plots have been divided into 3 general classes which include both species of rust fungi and both stem and trunk infections. The first class, which includes cankers estimated to be less than 3 years old, contains 60 percent of the 320 infections. The second class, including cankers estimated to be from 3 to 5 years old, contains 34 percent. The last class, which includes those infections estimated to be more than 5 years old, contains only 6 percent of the total number of cankers studied in these plots. These figures show that in the last 5 years there has been a great increase in the amount of rust infection, some of which was probably due to the growth of the host trees; in other words, there are now more limbs to be infected than existed a few years ago. It is also probable that a large amount of this infection was due to the increasing number of spore-producing cankers in and about these plots. As more and more cankers produce spores, oak infection has also doubtless increased, while this increased amount of oak infection serves to cause more pine infection, and so on.

Control Measures

Although nursery infection can probably be minimized by the complete eradication of all scrub oaks within 1,300 feet of the nursery, the removal of all pine cankers within this zone would also be desirable. Since heavy concentrations of infected oaks or of pine cankers at even greater distances may result in considerable infection, their removal would supply a further safeguard. Cutting back the oaks, which results in the growth of numerous sprouts with many leaves highly susceptible to rust infection, must not be considered as a means of eradication; this can be effected by the use of tree poisons, girdling,[1] or by pulling with tractors. Where planting stock is infected in the nursery, it should be carefully culled before being sent to the field for planting in order to eliminate all seedlings with abnormal swellings on the stems.

Infection in the field could be prevented by planting only on sites free from scrub oaks or by planting disease-free stock on sites from which all rust cankers have been removed. The use on diseased areas infested with scrub oaks of species known to be resistant to the rust canker is probably the best control method for most areas in the Southern States; under such conditions longleaf is probably the most desirable species.

There is probably little that can be done to prevent or control these diseases in natural stands in areas where scrub oaks are common. Until more is known as to the ultimate effect of the rusts, in areas where scrub oaks are numerous it would seem advisable to favor longleaf (or perhaps shortleaf) pine rather than pure stands of slash or loblolly.

Summary and Conclusions

From a survey of nurseries growing southern pines for reforestation, it has been learned that slash and loblolly seedlings are being infected in the seedbed with Cronartium rust. Nursery infection is more important in localities with large numbers of diseased pines and infected oaks about the nursery than in areas where natural infection is not abundant. Observations indicate that where scrub oaks are not present in the area about a nursery, the pine seedlings remain uninfected.

Observations made in plantations and in natural stands of slash and loblolly pines also demonstrate the importance of rust infection in the field, and data presented show how the disease tends to increase in severity from year to year.

By artificial regeneration and by natural means many commercial stands of longleaf have now been superseded by young forests of loblolly and slash. Also it is recognized that complete fire protection has served to favor the natural regeneration of these pines at the expense of longleaf. Extension of these susceptible species of pine to areas where scrub oak is abundant has produced conditions favoring rust epidemics, and heavy losses in some of the young forests are threatened by these native diseases through planting diseased nursery stock and through natural infection in areas where scrub oaks are abundant.

Several control measures for nurseries and plantations are suggested,

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1/ Bull, Henry, and Chapman, R. A. 1935. Killing Undesirable Hardwoods in Southern Forests. Occasional Paper No. 50. Southern Forest Exp. Sta., New Orleans, La.

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POSSIBLE RETURNS FROM PLANTED LOBLOLLY PINE

by

R. R. Reynolds, Associate Forest Economist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

POSSIBLE RETURNS FROM PLANTED LOBLOLLY PINE

by

R. R. Reynolds, Associate Forest Economist,
Southern Forest Experiment Station.

In setting up a calculation of costs and returns from planted stands of any species of southern pine, it must be borne in mind that information is not yet available on the behavior of such stands over a long period of time or throughout a rotation. Any calculations must therefore be more or less theoretical, and there is always the possibility that fire or insect damage may upset plans and expectations.[1] In this connection it might be well to caution against the planting of large areas to any one species and age-class of southern pine, especially loblolly. Since most planted loblolly stands in the South have been subject to severe attacks from tip moth, which have caused stunting and retardation of height growth during the first few years, consideration should be given to the possibility of planting slash pine in mixture with the loblolly in order to minimize this danger. The growth rate of the slash pine is as good as (or better than) that of loblolly, and observations indicate that slash will survive almost as low temperatures as loblolly, although the natural range of slash is restricted to a more southern belt.

As a basis for calculations in this paper, it is assumed that loblolly will be planted in pure stands, although the planting of slash pine with the loblolly probably would not materially affect the calculations here presented. It is also assumed that the trees will be planted 6 feet apart in rows 8 feet apart. With the stand established, the determination of returns and costs is made by applying current stumpage values and other economic data on the basis of the best available growth and yield data.

It is planned to do no thinning in the stand until the branches have died up to a desirable height and until most of the trees are merchantable for pulpwood. This will be when the stand is approximately 20 years of age. At that time, on an average site, the distribution of trees and volumes by diameter-classes should be approximately as shown under stand "before thinning" in table 1. This total volume of 1400 cubic feet is equivalent to 17.5 standard (4 ft. x 4 ft. x 8 ft.) cords (based on a converting factor of 80 cubic feet of wood per standard cord of rough wood).

When the stand is 20 years of age, it is planned to thin it in order to continue or increase the growth rate of the reserved trees; to improve the stand composition by removing the rough, crooked, and defective trees; and to salvage some of the trees that would otherwise be lost through mortality. It is assumed that this thinning will be made chiefly in the larger diameter-classes, since a certain proportion of the larger trees will undoubtedly be very limby and subject to the formation of black knots if left to grow. It is also planned to remove 6.6 cords per acre in this first thinning, after which the reserved stand will be as shown in table 1.

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[1] Owing to the fact that it is impossible to forecast accurately the increase in effectiveness of fire protection; the danger from loss caused by insects, sleet damage, windstorms, etc.; or the increase or decrease in the amount of taxes assessed against timberland in the next 40 years, this paper attempts only to serve as a basis for discussion and to give an indication of the possibilities of growing loblolly pine in planted stands in the South.

Table 1. Stand per acre 20 years old

Diameter at breast height	Before thinning		After thinning	
	Number of trees[1]	Volume[2]	Number of trees	Volume[2]
Inches		Cubic feet		Cubic feet
4	122	98	115	92
6	239	681	168	479
8	81	505	40	250
10	11	116	5	53
Totals	453	1400	328	874

1/ From table 162 of U.S.D.A. Miscellaneous Publication No. 50, but excluding those trees 4 inches in diameter or less which are severely suppressed. At present no final basis exists for determining the exact average yield from plantations. The above table, as well as the ones that follow, however, check with the best available information on planted and well-stocked natural stands.

2/ Volume in cubic feet of solid wood (inside bark) to a merchantable top-diameter, which varies with the size of the trees, the minimum being about 3 inches inside bark.

This thinning will open up the stand considerably and will leave only the best trees for additional growth, which it is reasonable to expect will correspond to that measured for similar stands. Based upon the best available data, therefore, during the next 8 years 35 percent of the trees in a given diameter-class will not move out of the present diameter-class; 50 percent of the trees in a given diameter-class will increase 1 diameter-class (2 inches); and 15 percent of the trees in a given diameter-class will increase 2 diameter-classes (4 inches).

In order to maintain this growth rate, it is planned to make a second thinning as soon as the stand has closed in, which should be at the end of about 8 years. Assuming the above rates of growth, the stand before thinning at the age of 28 years would be as shown in table 2. The total volume of the stand per acre is 1,928 cubic feet of wood, or 24.1 cords. This thinning, which will again remove trees from all merchantable diameter-classes in order to improve the quality of the residual trees, should remove approximately 10.5 cords per acre, leaving a residual stand as shown in table 2.

By assuming the same mortality and growth rates as during the first 8-year period, it is possible to predict the stand at the end of a second 8-year period or when the stand is 36 years old, at which time the distribution of trees and volumes by size-classes should be about as shown in table 3.

Table 2. Stand per acre 28 years old

Diameter at breast height	Before thinning		After thinning	
	Number of trees[1]	Volume	Number of trees	Volume
Inches		Cubic feet		Cubic feet
4	30.2	29	30.2	29
6	96.0	334	45.0	157
8	102.5	782	50.0	382
10	44.4	585	33.4	440
12	8.5	175	4.0	82
14	.8	23	-	-
Totals	282.4	1928	162.6	1090

[1] Mortality in an 8-year period is assumed to be 25 percent of the trees in the 4-inch class; 10 percent of those in the 6-inch class; and none in the 8- and 10-inch classes. Owing to the fact that most of this is a result of injury at the time of thinning, the stand table showing the number of trees after thinning is reduced by the above amounts before the resulting stand 8 years hence is calculated.

Table 3. Stand per acre 36 years old

Diameter at breast height	Before thinning		After thinning	
	Number of trees	Volume	Number of trees	Volume
Inches		Cubic feet		Cubic feet
4	7.9	9	7.9	9
6	25.5	96	20.0	75
8	41.2	352	26.0	222
10	42.8	653	32.0	488
12	25.6	611	25.0	597
14	7.0	236	6.0	203
16	.6	27	.6	27
Totals	150.6	1984	117.5	1621

The stand at 36 years of age would have approximately 24.8 cords to the acre. This would be available for pulpwood if everything were cut for pulpwood at this time, but the stand now has been nursed through the period when it is most susceptible to fire and to attacks from disease and insects, and it has reached the age at which reproduction can be obtained at little or no cost. With 33 trees (in the 12-inch and larger diameter-classes) large enough to be marketable for sawtimber and growing both in volume and quality at a very rapid rate, it would appear, therefore, to be extremely poor forestry and poor business, even for a pulpmill, to cut the stand clean for pulpwood at this period. The standard sawtimber stumpage price for loblolly pine sold from National Forests in 1937 was $7 per M board feet while the price for pulpwood stumpage was only $1 per cord. It is thus conservative to assume that 36 years from now the private owner will sell his pine sawtimber stumpage for $6 per M board feet and his pulpwood stumpage for $1 per cord, but assuming these stumpage values, those trees that will make either pulpwood or sawtimber would have a stumpage value of about $2 per M board feet when cut into pulpwood and about $6 per M board feet when cut as sawtimber. It would, therefore, be distinctly to the advantage of the forest owner to consider integrated utilization of his forest products, and to manage his property so that the maximum volumes of sawtimber can be cut at regular intervals.

Studies made in second-growth shortleaf-loblolly pine indicate that approximately one-third of the cubic volume of a sawtimber tree has a greater value for pulpwood than for sawtimber. Also it is desirable to make pulpwood thinnings and improvement cuttings in a sawtimber stand at approximately 8-year intervals, in order to maintain the growth rate and improve the quality of the sawtimber. Therefore, it will be possible to manage this planted stand so as to obtain a good continuous yield of pulpwood as well as a good continuous yield of high-value logs. Having decided upon this type of management, the cut at the 36th year will be limited to those trees that need to be removed to improve the stand and to maintain the growth rate. No logs will be cut at that time because of the smallness and poor quality of the trees (which are growing rapidly, however, both in volume and quality), but approximately 4.5 cords of pulpwood will be removed. The stand after the thinning is shown in table 3.

At the time of the next cut, 8 years later (when the stand is 44 years old), it should be possible to obtain about 2.8 cords of pulpwood and 1,300 feet of high-grade logs per acre. Beginning at 52 years, however, it should be possible to obtain 3.6 cords of pulpwood and 3,000 board feet of high-quality sawlogs every 8 years under sustained-yield forest management.

Financial Calculations

With land valued at $4 per acre, planting costs at $4 per acre, and the interest rate at 3 percent,[3] it seems desirable to determine the cost of planting and carrying the stand through the 36th year, based on both present and estimated future current expenses. In a large part of the South at the present time, taxes per acre on planted or natural second-growth stands amount to 12¢ or less a year. Fire protection costs timberland owners 2¢ (with the Federal Government matching this amount), and administration costs are approximately 5¢ a year. This makes a total annual current expense of 19¢ an acre. Although it is very unlikely that current expenses will double in the next 36 years, the costs of growing the stand through the 36th year both under present costs and under costs double those at present are shown in table 4.

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[3] Interest rates for borrowed money usually run from 5 to 7 percent, but these include risks and costs to the lender. Earnings of most forms of investment seldom net over 3 percent compounded.

Table 4. Costs of planting and growing loblolly pine for 36 years under present costs and under costs twice the present ones

Item	With present costs for taxes, fire protection, and administration	With twice present costs for taxes, fire protection, and administration
Interest on investment in land ($4) compounded at 3% for 36 years	$7.59	$7.59
Cost of planting investment ($4) plus interest compounded at 3% for 36 years	11.59	11.59
Cost of taxes, fire protection, and administration paid annually for 36 years, plus interest compounded at 3% (Present costs per acre are taxes 12¢, administration 5¢, and fire protection 2¢.)	12.02	24.04
Total cost of stand during 36 years	$31.20	$43.22

With pulpwood stumpage worth $1 per standard cord, the value of the various thinnings compounded at 3 percent through the 36th year would be as follows:

6.6 cords cut at the 20th year at $1 per standard cord plus interest compounded at 3% for 16 years	=	$10.59
10.5 cords cut at the 28th year at $1 per standard cord plus interest compounded at 3% for 8 years	=	13.30
4.5 cords cut at the 36th year at $1 per standard cord	=	4.50
Total		$28.39

The value of the pulpwood cut from the stand as thinnings up to the end of the 36th year is $28.39, including interest at 3 percent. This is in addition to the growing stock remaining, which is equivalent to approximately 20.3 cords, worth $20.30, if valued only for pulpwood. Thus, if figured on a 36-year pulpwood rotation at 3 percent compound interest, the total gross return per acre is $48.69, while the total cost is $31.20, based on present expenses, or $43.22 if based on estimated future expenses; this leaves a net income of $17.49 per acre, based on present expenses, or $5.47 based on increased expenses. The average annual net income per acre per year is therefore 49¢ if present costs continue, or 15¢ if current costs increase 100 percent. There is a very real possibility, however, that pulpwood will double in stumpage value within the next 20 years, and if such were the case the average annual net income would amount to $1.84 per acre if based on present current expenses, or $1.50 if based on the estimated future current costs. Thus, with a substantial increase in pulpwood stumpage values, the planting of loblolly or other pines would be very profitable.

In comparison with a system of management which would grow and cut all trees 4 inches and over d.b.h. for pulpwood on a 36-year rotation, a system of selective timber management with integrated utilization appears to be more profitable. Under the latter system, regeneration is obtained naturally in openings, following cutting of sawtimber trees, without the cost of planting. Also, the serious fire and insect hazard that is always present in young, even-aged stands covering extensive areas is much less serious in those scattered patches of young pine that under selective timber management occupy only about 10 percent of the total area. Beginning at age 36, and continuously thereafter, the total costs per acre for 8 years of management, including annual costs of 19¢ and interest compounded at 3 percent, amount to $1.69. If doubled, these costs would be $3.38. The gross income per acre at the end of the first 8-year period, or when the stand is 44 years old, is estimated to be $10.60, including $7.80 from sawtimber stumpage (1,300 board feet at $6 per M) and $2.80 from pulpwood stumpage (2.8 cords at $1 per cord). The net income per acre for the 8-year period is $8.91, using present management costs, or an average of $1.11 per year. If these costs should double, the net income per acre would be $7.22 or 90¢ per year. The timber at this age is still relatively small, and the cut is more of an improvement cutting than a harvest cutting.

Beginning at age 52, however, when many of the trees have reached sizes desirable for sawtimber, and continuously thereafter, at 8-year intervals, it is estimated that a gross income of $21.60 per acre can be obtained; this includes $18.00 from sawtimber stumpage (3,000 board feet at $6 per M board feet) and $3.60 from pulpwood stumpage (3.6 cords at $1 per cord). This is equivalent to a gross income of $2.70 per acre per year. The net income per acre for each 8-year period with present costs of management would be $19.91, or $2.49 per year, and with doubled costs would be $18.22 or $2.28 per year. With a good growing stock always present on the ground, it is possible to take advantage of market conditions and to cut those products that have the greatest value, while this is not possible with even-aged pulpwoo rotations. With present indications that future markets will recognize and pay accordingly for the better grades of stumpage, this selective method of cutting promises to become increasingly profitable.

Conclusions

Table 5 has been prepared to show more clearly the number of trees before and after each cut and their movement into larger diameter-classes during each 8-year period.

It should be noted that some natural reproduction is expected to become established following the thinning at 28 years after planting. More reproduction, of course, can be expected following later cuttings, when larger trees have been cut and larger openings made. Since sufficient trees are retained in the stand to guarantee the amount of production indicated through at least 80 years, the amount of natural reproduction that is necessary in any one 8-year period to perpetuate the stand is relatively small. If normal reproduction does become established, it is apparent that the yearly production of pulpwood may be greater than that indicated, since a considerable proportion of the naturally reproduced trees will be removed in later thinnings.

Table 5. Number of merchantable trees per acre by diameter-class and stand age

Diameter at breast height	Stand age 20		Stand age 28		Stand age 36		Stand age 44		Stand age 52	
	Before thinning	After thinning	Before thinning	After thinning	Before thinning	After thinning	Before thinning	After thinning	Before thinning	After thinning
Inches	Number of trees									
4	122	115	30	30	8	8	20	18	20	19
6	239	168	96	45	25	20	14	11	15	15
8	81	40	102	50	41	26	20	18	13	10
10	11	5	44	33	43	32	26	25	19	18
12			9	4	26	25	26	22	24	22
14			1		7	6	17	13	20	13
16					1	1	6	4	12	8
18							1	1	4	2
20									1	1
Total merchantable trees	453	328	282	162	151	118	130	112	128	108
Total cords in trees 4 inches to 12 inches d.b.h. inclusive	17.5	10.9	23.8	13.6	21.5	17.4	16.9	15.0	15.7	13.0
Total cords cut each cycle[1]		6.6		10.5		4.5		2.8		3.6
Total volume in board feet in trees 14 inches d.b.h. and larger			178		1,689	1,473	6,317	4,739	11,244	7,639
Total board-foot volume cut each cycle								1,300		3,000

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[1] From tops of sawlog-size trees as well as from entire trees.

From the above computations, evidently it should prove reasonably profitable for any Southern pulp company or land owner that can obtain productive forest land at a relatively low cost, to initiate a planting program, or, where naturally regenerated lands are available, to acquire well-stocked young stands for the commercial production of timber. For the pulp company, such an undertaking would insure future wood supplies for a period long enough to depreciate the plant investment economically. By planting areas within easy trucking distance of the pulpmill, companies could save freight charges of 75¢ to $2 per cord, and these savings might well be credited to stumpage values. With sawtimber stumpage worth two to four times the value of pulpwood stumpage, it evidently will pay the timberland owner to sell as much of his stumpage for sawtimber as he can, but also to take full advantage of available pulp markets in order to dispose of poor-quality material removed in stand improvement and from tops of sawtimber trees. A planting or acquisition program of 5,000 to 10,000 acres a year over a period of 10 to 15 years would not represent a very large investment and under skillful management should yield liberal returns.

OCCASIONAL PAPER NO. 74 JULY 23, 1938

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TAXATION OF FOREST LAND IN THE YAZOO DELTA OF MISSISSIPPI

by

Ronald B. Craig, Associate Forest Economist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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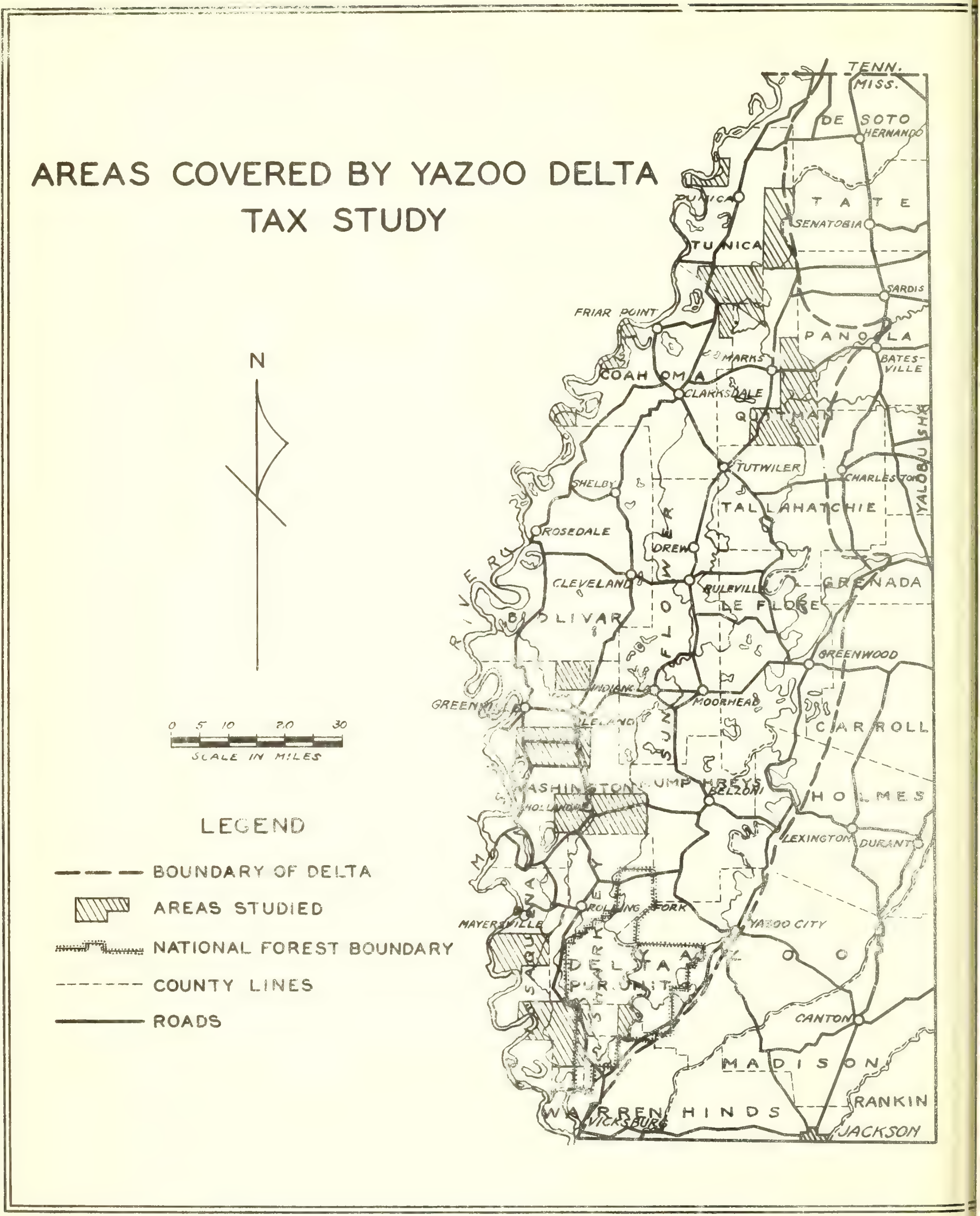

AREAS COVERED BY YAZOO DELTA TAX STUDY

FIGURE 1

TAXATION OF FOREST LAND IN THE YAZOO DELTA OF MISSISSIPPI [1]

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INTRODUCTION

Purpose of study

The purpose of this study is to determine the current total property tax on forest land in the Yazoo Delta of Mississippi, the relative importance in this total of the levies made by the several taxing authorities, and the relation of forest taxation to the future possibilities for private forestry. The study was undertaken to provide information that would aid the Southern Forest Experiment Station and other agencies that are seeking to appraise the land-use possibilities and the forest economy of this important forest region.

Location of area surveyed

The name Yazoo Delta is applied to the roughly elliptical area of the Mississippi River alluvial plain in Mississippi, bounded on the west by the river and on the north, south, and east by the line of loessal bluffs marking the eastern edge of the original flood plain of the river (fig. 1). This region, comprising all or parts of eighteen counties, has an area of 4,420,400 acres, of which 1,736,900 acres (39 percent) is hardwood forest land (7).[2] Fifty-two percent of the area (2,319,700 acres) is in cultivation, cotton being the principal crop, with corn second. The forest land lies, for the most part, in two types of location: (1) on the Mississippi River batture (the land between the main levees and the bank of the river), and (2) on the interstream swales in the drainages of the Yazoo River and its principal tributaries, the Tallahatchie, Coldwater, and Sunflower Rivers. All these streams being aggrading rivers, the areas nearest their banks are built up higher than the interstream swales, except where two or more streams unite, in which case the surrounding territory is generally low and subject to annual overflow (e.g., the area around the junction of the Coldwater, Tallahatchie, and Yocona Rivers in Quitman County). In general, all land now economically suitable for cotton or corn production has been put in crop, although there is a considerable acreage of potential cropland, which, with draining and improvement, could be cultivated if market conditions should warrant its use for this purpose.

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[1] The author extends his sincere thanks to all who aided in this study. Cordial and helpful cooperation was provided especially by the Delta Chamber of Commerce, the Mississippi State Planning Commission, the Mississippi State Tax Commission, and by all county officials in the Yazoo Delta.

[2] Figures in parentheses refer to list of literature cited at the end of this paper.

Since this study was concerned only with forest land, and since available funds permitted only a relatively small area to be intensively studied, the sample areas were confined to five counties. The counties chosen among the ten all-Delta counties, after consultation with all cooperating agencies, were, from north to south, Tunica, Coahoma, Quitman, Washington, and Issaquena. The reason for selection of these counties was their representative character in respect to geographical location, land use, tax delinquency, and taxes per acre. Within each county, all public-land survey townships which were 50 percent or more forested, as determined by aerial survey maps of the Delta, were listed, and a definite number was selected in each county in such a way as to give the widest possible distribution of area within each county. The tendency noted above for the forest land to be concentrated either on the batture or in the interior overflow lands prevented a randomized distribution of sample areas over any entire county. The sample townships are shown in figure 1. Within each sample township, every ownership reported on the county Land Roll as totalling 250 acres or more in gross area (cultivated, pasture, and forest land) was listed and included in the study.

Method of study

The following data were recorded for each Land Roll description of each sample property:

1. Owner's name.
2. Location of property (by Public Land Survey description).
3. Area by land-use classes as reported on Land Roll.
4. Assessed value of each class of land and of improvements.
5. Location in respect to general and special taxing districts.
6. Drainage benefit assessment, if any.

In addition to these data, copies were obtained of the tax levy order of the Board of Supervisors of each county for 1936, and a statement obtained from each drainage and levee district of the tax rate imposed by it, and in the case of drainage districts, of the benefit assessment. From all these data, the total property tax in 1936 was computed for each levying agency (state, county, school, road, levee, and drainage districts) on each description. In order to determine the relation between drainage benefit assessment and assessed value for ad valorem tax purposes as of the same year, for each sample property in a drainage district data were also obtained on the assessed value as of the year in which the particular drainage district made its benefit assessment.

All properties in the selected townships which were shown on the 1936 Land Roll [3] as State title on Jan. 1, 1936, for non-payment of taxes were listed, the following data being taken for each:

1. Year of forfeiture (i.e., original tax sale).
2. Name and occupation of original owner.
3. Location.
4. Area by land-use classes as of year prior to that of forfeiture.
5. Assessed value by above classes for indicated year.
6. Ad valorem, levee, and drainage taxes levied in year prior to that of forfeiture (for the non-payment of which the property forfeited).
7. Name and occupation of patentee, if any (only, of course, for patents issued between Jan. 1, 1936, and date of study, here considered as Apr. 1, 1937).

STRUCTURE OF LOCAL GOVERNMENT IN MISSISSIPPI

The structure of government in Mississippi is much like that in other Southern States. The State exercises only nominal advisory powers in relation to local government, the individual counties and municipalities being given almost a free hand in matters of finance and taxation. The State levies a property tax, poll tax, various excise taxes and privilege taxes, and a 2-percent general-sales tax. The counties have, as indicated, nearly unlimited powers in respect to taxation and can levy property taxes, a few per capita taxes (dog tax, commutation road tax, etc.), limited privilege taxes, and excise taxes (especially on gasoline). The counties are divided into "beats" for voting and judicial procedures, but the beats are not taxing agencies.

Schools and roads are financed according to the wishes of each county. In some counties there are no special school districts, all school taxes being levied at a uniform rate throughout the county and disbursed by the county Board of Education and Board of Supervisors. In other counties, as many as 15 special school districts have been set up, each of which may have a different tax rate and may handle all its own finances, subject only to approval of a majority of the qualified electors in that district. A similar condition obtains in respect to road districts, although there is an increasing tendency in many counties to abolish small special road districts in favor of one county-wide district.

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[3] The various public records referred to throughout this study, or used as sources of the data, are as follows:

a. "Land Roll" - the county assessment roll for "acreage" (unplatted) lands. Assessment of such lands is biennial, in even years.
b. "Abstract of Titles" - the county abstract of property transfers, including patents issued by State for tax-forfeited lands.
c. "List of Lands Sold to State" - the annual county register of properties "struck off" to the State at the sheriff's sale of tax-delinquent lands. This list, which does not include sales to individuals, also shows data on redemption and/or ultimate maturity in State of each property so listed.
d. "Drainage District Benefit Assessment Roll." This roll, which is not a county record but is kept by each individual drainage district at the district office, shows the total benefit assessment against each description of property in that district and also shows (in most cases) the percentage rate levied annually on the said benefit for taxation purposes.

There are two levee districts in the State, dealing, however, only with the main levees along the Mississippi River. The other districts responsible for levees in the Yazoo drainage are organized in all cases as "drainage" districts, to be discussed presently. The two levee districts are (1) the Mississippi River Levee District, comprising all of the counties of Bolivar, Washington, Sharkey, and Issaquena, and that part of western Humphrey County which was a part of Washington County in 1865, when this district was organized; and (2) the Yazoo-Mississippi Delta Levee District, comprising the rest of the Delta proper. They are completely independent of the county governments. Their methods of taxation differ somewhat, but are essentially the same so far as taxes on land are concerned. Both levy an ad valorem tax on all real and personal property and a tax of 2¢ per acre on all rural land within their respective districts. Both levy certain privilege taxes (though not the same ones), and the Mississippi River District levies also a commodity tax on cotton produced within the district.

In the State there are 273 drainage districts that have bonds outstanding, of which 110 are in the Yazoo Delta. They vary in size from less than 1,000 acres to more than 75,000 acres. They were organized, under various laws of the State, for the purpose of draining land suitable for agricultural purposes, or, through levee construction, of protecting such land from overflow. Like the levee districts, they are entirely independent of the county governments and subject only to the provisions of the laws under which they were organized, as interpreted and enforced by courts of competent jurisdiction. Their methods of raising funds for construction and maintenance of improvements vary, including benefit assessments, acreage taxes, and ad valorem taxes. Since these drainage taxes constitute the major land tax burden in the Delta, they will be discussed in more detail in connection with the specific areas studied.

LAND TAXATION

The preceding section of this report has dealt with the general structure of government in Mississippi as a whole. This section deals with the methods of levying and current rates of taxes on real estate in the five selected counties and their subdivisions, and in the levee and drainage districts within or partly within their boundaries.

State tax

The only State tax with which this study is concerned is that on land. The State property tax is, of course, levied on both real and personal property, but this study is concerned only with the land tax. Homesteads are exempt from State tax to a limit of $2,500 of assessed value. The State funds derived from the property tax are used for common schools, pensions (chiefly Confederate), and general purposes. In 1936 the rate of

State property tax was 8 mills per dollar of valuation, but in 1937, owing to the excellent financial condition of the State, Governor White reduced the rate to 4 mills, to be effective Jan. 1, 1938.

County, school, and road taxes

The general administration of county taxation is uniform in all the counties covered by the study. The Board of Supervisors, with the completed tax digest before it and with its budget determined, computes the rates necessary to raise the required revenue for each purpose of disbursement, and issues an order levying the determined rates on each dollar of property subject to taxation in the county. It is only the inclusion or exclusion of school- and road-fund levies that varies among the counties. Every county is required by law to levy a county-wide tax for common-school purposes. In many counties, however, the proceeds of this tax are used only for an equalization fund and for actual costs of administration by the county Board of Education and similar purposes, the maintenance, debt service, and incidental costs of local schools being met by the setting up of special school districts, each of which levies a tax at a rate determined by the district Board of Trustees. These special district levies must be approved by a majority of the qualified electors in the district; otherwise the district board has full authority for these purposes. Among the five counties studied, Issaquena is the only one without special school districts. Tunica County has three such districts, covering only about a third of the county, the remainder of the county being outside any special district. Coahoma County has 8 districts, covering about half the county; Quitman County, 12 districts, covering almost the entire county; and Washington County, 11 districts, covering all but a few thousand acres of the county.

The same general situation exists in respect to road districts, except that the county government, through the road district supervisor, controls the special road districts. Each county levies a county-wide tax for road purposes, whether or not it has special road districts. The people in a given area of the country, however, may organize a special district, as in the case of schools, and, by vote of a majority of the qualified electors resident in the district, levy a special tax for the purposes of road construction or improvement. Among the five counties, Washington alone has no special road districts, although Issaquena and Coahoma have but one each. Tunica has seven special districts or subdistricts, and Quitman has nine (including subdistricts).

The "county general" tax rate (exclusive of State, special school and road, levee, and drainage taxes) in 1936 was as follows: Tunica, 20 mills; Coahoma, 17 mills; Quitman, 17 3/4 mills; Washington, 26½ mills; and Issaquena, an average of 25½ mills, with variation among beats.

The rates for the numerous special school and road districts are, of course, variable. In general, school district rates ranged from 1 to 10 mills, with a few rates up to 13 mills, while road district rates ranged from 1 to 12 mills. In this connection, however, mention must be made of the gravest problem in connection with special district taxation. This is the multiplicity of overlapping or pyramided special districts. Some districts have been superimposed on earlier districts, and the properties therein are then subject to the levies of both districts. When, as is sometimes the case, this has occurred with both school and road districts in relation to a particular property, the resulting taxes may become extremely burdensome. An even more aggravated form of this practice is found in drainage districts, but it is too prevalent even with school and road districts.

Levee district taxes

The levee taxes imposed on land in the Lower (Mississippi River) District are: (1),a flat levy of 2¢ per acre, and (2), an ad valorem levy at the rate of 3 mills per dollar. The commodity tax on cotton (2 mills per pound), although paid by the rural land owner, is not a direct tax on the land which produced the cotton.

In the Upper (Y.M.D.) district, the acreage tax is also at the rate of 2¢, but the ad valorem tax rate varies between the "front" (facing on the river) counties, and the "back" counties. In the former counties (De Soto, Tunica, and Coahoma) the rate is 4.40 mills, and in the "back" counties 3.19 mills.

Drainage district taxes

As stated previously, the complexity, as well as the importance, of the drainage-tax problem requires detailed consideration. Drainage districts have been organized under enabling legislation of 1906 and 1912 (and amendments) for the purpose of draining land or protecting it from overflow "for the promotion of public health and for agricultural purposes" (Chapter 195, Laws 1912, as amended by Chapter 269, Laws 1914). The drainage district is a "body corporate and politic" (Secs. 4401 and 4450, 1930 Code), and hence it can issue bonds.

The basis of determining drainage-benefit assessments is not clearly defined. The common legal basis for assessing special benefits is the distribution of the total cost of the improvements among the properties affected, in proportion to the value added by the improvement, but in no case exceeding the value presumed to be added thereby. In the case of the Delta drainage districts, however, there is absence of evidence, either in the laws or in relevant data subsequently acquired, that this principle was adopted. The basis of assessment appears to have varied widely from district to district, the actual assessment seldom being predicated on any clear-cut principle. In some districts the assessment may have represented nothing more than a following of the line of least political resistance.

As to method, the Board of Drainage District Commissioners determines the benefit assessment against every piece of real property in the district, which assessment must be approved by the Chancery Court. This benefit assessment is fixed once and forever at so much per acre immediately subsequent to organization of the district. This per-acre assessment is then multiplied by the total acreage in the given property to arrive at its total benefit assessment. On this benefit assessment a percentage tax, ranging generally from 1 to 5 percent and uniform throughout the drainage district, is levied; or, in some districts all the benefit assessments are due and payable on order of the Court either immediately or in installments. In actual practice, the district benefit assessment, in the aggregate, is merely the total amount of revenue required for construction, maintenance, organization, and contingent costs, in the form of principal and interest payments on the bonds issued to cover those costs. A common procedure is to make the district benefit assessment equal to three times the face of the bond issue, in order to be prepared for possible tax delinquencies and other contingencies. As can be seen, the so-called benefit assessment is, in practice, based on the prospective future need for revenue, with no relation to the actual benefits derived from the drainage ditch.

In the event that property in a drainage district forfeits to the State for unpaid taxes (State and county, or drainage, or both), the lien of the district is not extinguished but is merely suspended, and on sale of the property to a private person under patent title from the State, the drainage district lien reattaches. A drainage district may bid in and retain title to, or subsequently sell, lands forfeited for nonpayment of drainage taxes.

There are three major types of drainage-district taxes imposed in this State. In the majority of districts, taxes are assessed as a percentage of the benefit assessment. In a few other cases, a flat acreage tax is imposed, that is, a tax of so many cents per acre uniformly throughout the district. In still fewer cases, chiefly in those districts in liquidation or dissolution, the tax is a flat ad valorem levy on the current assessed valuation, as determined for the levying of State and county taxes, at a millage rate determined by the Board of District Commissioners and approved by the Chancery Court.

Mention has been made previously of the evil of overlapping tax districts. This is especially notorious in the case of drainage districts. Indeed, a map of the drainage districts in some counties (especially those along the Tallahatchie, Coldwater, and Yocona Rivers, and the upper Yazoo River which these tributaries unite to form) resembles a set of superimposed jig-saw puzzles. In a few cases among the five counties studied, individual properties lay in three drainage districts and were consequently subject to the tax levies (as a percentage of benefit assessment, or as acreage tax, or both) of all three districts. Obviously, such a condition at the current tax rates is almost prohibitive of private ownership of property, as evidenced by the marked concentration of tax-forfeited land matured in State title in these areas. Were it not for the compromising of delinquent drainage taxes, the area in State title would be much larger.

VARIATIONS IN ASSESSMENT PRACTICE AND IN CONCEPT OF ASSESSED VALUES

State-wide legal classification of land

Mississippi classifies her rural lands into three types for taxation purposes. These are legally defined as follows (Sec. 3145, 1930 Code):

"Cultivatable lands:

(a) Lands which were in cultivation during the year previous.

(b) Lands which were ready for the plow on January 1.

(c) Lands susceptible of cultivation, but are used for pasture, or are unused — 'lying out.'

(d) Lands with soil and surface suitable for agriculture but covered, entirely or partly, with shrubbery which has grown up through lack of use, but which may be cultivated with the ordinary annual clearing.

"Timbered lands:

(e) Lands covered with merchantable timber; that is, regardless of kind, timber which can be sold in the market. It would necessarily be timber out of which lumber, ties, staves, spokes, shingles, boards, heading, pulpwood, laths, etc., could be made. Land covered by small trees (out of which the foregoing cannot be made, but out of which firewood can be made) are not to be classified as timbered lands but as uncultivatable lands, if the soil and surface are not susceptible of agriculture, or trees or undergrowth are so dense that the lands cannot be cultivated without unusual clearing.

"Uncultivatable lands:

(f) Gullies, sand beds, and hills, which cannot be used for agricultural purposes; low lands which are so often overflowed that they cannot be used for agriculture.

(g) Lands so thickly in stumps or small trees as not to be susceptible of agriculture.

(h) Lands so lacking in fertility that the soil is not capable of producing crops by the use of ordinary methods of preparation and the ordinary use of fertilizer."

Local concepts of classification and value

The above definitions of the three land classes, while written into the statute code of the State, are not strictly or uniformly followed in all counties. Indeed, while the Legislature doubtless intended arability to be the major basis of classification, no attempt has been made in the counties studied to classify land on its crop-producing capacities. In actual practice, only lands falling in the groups defined under paragraphs (a), (b), and (c) are classed as "cultivatable lands," those falling in the (d) group being classed as "uncultivatable." Furthermore, there is wide variation among the counties in the concept or interpretation of "timbered" land and of "uncultivatable" land under group (g). In all counties studied, except Issaquena, no land is classed as "timbered" on the Land Roll unless there is an assessed volume of timber on it, although the actual volume in board feet present on the ground may frequently be very different from that shown on the Land Roll. In Issaquena County, however, it was noted that thousands of acres on which no timber is assessed or even present on the ground are assessed as "timbered" land. An explanation was made locally that these lands had been so classified originally when timber was present, but that, when the timber was removed, the classification was not changed, although the assessment of the standing timber was dropped from the roll. The assessment per acre is in general the same for all such lands, irrespective of classification as "timbered" or "uncultivatable." Similar conditions doubtless obtain in other Delta counties not included in this study.

This statement raises another serious problem, arising through the very means by which its solution was attempted. Analysis of actual practices (as distinguised from legislative intent) in property classification in the Delta (and probably throughout the State) reveals that if taxable land is not properly classified, the purposes for which the classification was originally made will not be accomplished. The outstanding example of this, as just indicated, is the "freezing" of assessed values at a uniform figure for all land in each class (particularly on "timbered" and "uncultivatable" land) throughout an entire county. For example, in Washington County all "uncultivatable" lands and all "timbered" lands, except on the batture and a few scattered tracts, are assessed at $5 per acre, and all timber, except on the batture, is assessed at $6 per thousand feet board measure, quite irrespective of location, condition, or any other factor affecting its actual market value. This condition obtains, under the present system of land classification, in spite of official advice from the State Tax Commission that location, condition, soil fertility, and similar factors are to be taken into consideration in assessing land within each land class, and that "actual value should govern, not the classification"(6, p. 27).

In tables 1 and 2 are presented data on the area in each land class in the county and in the sample studied, the average assessed value per acre of each land class in the county as a whole, and the average of, and range in, assessed value per acre of each land class within the samples. These tables are self-explanatory.

Table 1.-Area of classes of land in county and in samples studied - 1936[1]

County	Cultivatable land			Uncultivatable land			Timbered land		
	Area in county	Area in samples	Ratio of sample to county area	Area in county	Area in samples	Ratio of sample to county area	Area in county	Area in samples	Ratio of sample to county area
	Acres	Acres	Percent	Acres	Acres	Percent	Acres	Acres	Percent
Tunica	131,882	10,615	8	94,758	21,342	23	18,045	3,657	20
Coahoma	219,575	1,523	1-	77,477	5,943	8	39,881	8,656	22
Quitman	117,748	4,820	4	93,061	18,322	20	406	195	48
Washington	249,898	12,761	5	154,083	25,095	16	6,662	1,162	17
Issaquena	66,213	9,520	14	97,657	35,414	36	58,400	23,280	40

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[1] Data from recapitulation of county Land Rolls (5) and from rolls of sample townships for 1936.

Table 2. - Average of, and range in, assessed values per acre by classes of land - 1936[1]

County	Cultivatable land			Uncultivatable land			Timbered land		
	County average [2]	Sample average [3]	Range in sample [3]	County average [2]	Sample average [3]	Range in sample [3]	County average [2]	Sample average [3]	Range in sample [3]
	Dollars								
Tunica	29.33	24.81	13.12 - 43.65	3.20	2.23	1.25 - 5.00	2.07	1.97	1.50 - 2.00
Coahoma	31.19	[4]24.83	21.00 - 31.25	6.57	[4]3.44	[5]1.00 - 7.00	2.01	2.00	2.00 - 2.00
Quitman	26.53	25.94	20.00 - 60.00	2.57	2.69	1.11 - 4.05	2.09	1.85	- 1.85 -
Washington	27.41	24.49	15.00 - 37.54	4.64	5.00	4.78 - 5.98	3.21	5.00	5.00 - 5.00
Issaquena	19.79	19.90	15.00 - 20.00	3.71	4.00	[5]0.02 - 6.01	3.52	4.09	[5]1.02 - 4.50

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[1] Data from county Land Rolls for 1936.

[2] Average value per acre of all land in given class in entire county.

[3] Average of, and range in, values of land in given class in sample areas only.

[4] Sample average is much lower than county average because the bulk of the sample area lay in the batture, where assessments are much lower than on protected land behind the levees.

[5] On batture land.

It will be noted that all the counties except Issaquena are primarily agricultural in character, the area classed as "cultivatable land" exceeding the combined area classified as "uncultivatable" or "timbered." In Issaquena County, however, the uncultivated area is 2½ times as large as the cultivated area. Since this study was concerned primarily with forest land, the portion of "uncultivatable" and "timbered" land included in the sample greatly exceeded the portion of "cultivatable" land so included.

In respect to county average assessed values per acre, it will be noted that with four or five obvious exceptions there are only slight variations among the five counties in this value for any one land class.

One fact not revealed by table 2, but of importance in relation to later data on tax per acre, relates to an assessment practice in Tunica County. In order to equalize the tax per acre between lands inside and outside drainage districts, Tunica reduces the assessment on lands in drainage districts to such an extent that the high tax rate on these lands will result in a tax per acre approximately equal to that produced by a low tax rate (i.e., without drainage tax) on the higher assessments of lands outside drainage districts. In general, "uncultivatable" lands are assessed as follows in this county:

In drainage districts	- $1.60 per acre
Outside drainage districts	- 4.50 per acre
Batture lands	- 2.00 per acre

Comparable adjustments are made in assessed values of other classes of land. Although this practice may not have had any conscious objective, it is in part justified by the capitalization of the higher taxes levied on land in drainage districts, the effect of which is to reduce the actual value of lands in those districts. No other county among the five studied makes such a distinction in assessing lands in respect to their location inside or outside drainage districts, although batture land is assessed in all counties at much lower values than protected land behind the levees.

The distribution of the area of the sample in each land-class by assessed values per acre is shown in table 3. In all counties except Tunica, most of the "cultivatable" land was assessed at $20 to $24.99 per acre. In Tunica County, owing to the assessment methods previously described, there is a much wider distribution of assessed values per acre. Most "uncultivatable" land is assessed at $1 to $4.99 per acre, and timbered land at the same rate. In Washington County, however, almost all the "uncultivatable" and "timbered" land other than batture land is assessed uniformly at $5.00 per acre. The total sample area was 182,305 acres, or 13 percent of the total area of these five counties.

Timber is assessed only if currently merchantable in local practice (see legal definition of "timbered" land, page 8). The range in assessed values is not shown since there is no significance in such a range when the individual values, with few exceptions, are so nearly uniform. The following tabulation shows the number of thousands of board feet assessed in each county and the county average assessment per thousand board feet.

County	Volume assessed	Assessed value per M bd. ft.
	M bd. ft.	Dollars
Tunica	12,977	5.06
Coahoma	11,395	5.00
Quitman	1,590	3.15
Washington	4,645	4.34
Issaquena	42,595	6.00

Effect of concept of agricultural value on assessed values of forest land

It has been shown by many studies of assessed values of rural land throughout the nation that the dominant land use in the taxing unit (county, township, or district) determines in large measure the concept governing the assessment of the various classes of land. For example, in a county where the dominant land use, from either the areal or investment viewpoint, is agricultural (crop or livestock production), there is a definite tendency to regard and assess all land as potential agricultural land. On the other hand, in a county where the dominant land use is timber production (or that of such a byproduct as naval stores), there is a tendency to assess all land at lower values, or at least at values close to those of forest land. Assessment practice in the Yazoo Delta is also strongly influenced by the future expected demand for large areas of agricultural land.

Coahoma County is an example of the tendency to assess forest land at an agricultural-value level. As shown in tables 2 and 3, "uncultivatable" land in this county is assessed much higher than in any other of the five counties (average, $6.57 per acre). Reference to table 1 shows that Coahoma County land is overwhelmingly agricultural as compared with land in the other counties. Issaquena County is an example of the opposite tendency. It will be noted (table 2) that agricultural land in this county is assessed at the lowest level of any county, while its 'cultivatable' land comprises only 30 percent (also lowest percentage for these counties) of the rural area.

This practice is not without some justification, of course, since it is true that in the Delta the high-quality soils of much of the uncultivated areas will, on proper drainage and clearing, yield abundant crops. It should be pointed out, however, that soil value, per se, does not enter into the assessment as now made, and that the practice of freezing of values by land class, rather than actual assessment of the true value of each individual property in each class and all of its component parts, tends in Coahoma County, for example, to overassessment of much 'uncultivatable' (or more accurately uncultivated) land and in Issaquena County (as the other example) to underassessment of much cultivated land. Relative accessibility, which is sometimes considered in assessing cultivated lands, may account in small part for these differences, but the above data indicate that one major factor in assessment is the dominant land use of the county. This conclusion was also confirmed by discussions with county officials.

Table 3.- Acreage distribution of assessed values per acre of land in sample, by classes of land[1]

Land class	Assessed value	County											
		Tunica		Coahoma		Quitman		Washington		Issaquena		Total	
	Dollars	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Cultivatable	10.00-14.99	70	1	-	-	-	-	-	-	-	-	70	[3]
	15.00-19.99	2,976	28	-	-	-	-	272	2	185	2	3,433	9
	20.00-24.99	2,149	20	945	62	2,210	46	6,121	48	9,335	98	20,760	53
	25.00-29.99	3,500	33	-	-	1,458	30	3,346	26	-	-	8,304	21
	30.00-34.99	1,568	15	578	38	1,150	24	1,242	10	-	-	4,538	11
	35.00-39.99	104	1	-	-	-	-	1,780	14	-	-	1,884	5
	40.00-44.99	248	2	-	-	-	-	-	-	-	-	248	1
	45.00 & up	-	-	-	-	[2] 2	[3]	-	-	-	-	[2] 2	[3]
	Total	10,615	100	1,523	100	4,820	100	12,761	100	9,520	100	39,239	100
Uncultivatable	0.01- 0.99	-	-	-	-	-	-	-	-	2,013	6	2,013	2
	1.00- 4.99	21,330	100	3,997	67	18,322	100	252	1	33,319	94	77,220	73
	5.00- 9.99	12	[3]	1,946	33	-	-	24,843	99	82	[3]	26,883	25
	Total	21,342	100	5,943	100	18,322	100	25,095	100	35,414	100	106,116	100
Timbered	1.00- 4.99	3,657	100	8,656	100	195	100	-	-	23,280	100	35,788	97
	5.00- 9.99	-	-	-	-	-	-	1,162	100	-	-	1,162	3
	Total	3,657	100	8,656	100	195	100	1,162	100	23,280	100	36,950	100
Grand total of all classes-acres		35,614	-	16,122	-	23,337	-	39,018		68,214	-	182,305	-
Percent of total rural taxable area		15.7	-	5.4		11.1	-	9.5		38.9	-	13.8	-

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[1] Exclusive of all improvements. Assessed values derived from county Land Rolls 1936.
[2] Two acres at $60.00.
[3] Less than 0.5 percent.

TAXES PER ACRE ON FOREST LAND

As stated previously, agricultural land use in most counties of the Delta is so intensive that idle or abandoned crop land is practically nonexistent. Hence almost all "uncultivatable" land is, in reality, forest land either clear-cut or bearing timber under sawlog size. For this reason all lands of this class, together with those of the "timbered land" class, have been grouped in tables 4 and 5 as "forest land."

In table 4 are shown the area and the average tax per acre of forest land in the sample, classified in accordance with the levee and drainage protection afforded. Batture land is subject only to State and county general taxes, since it does not have the benefit of schools or roads (very few persons live between the main levees and the river bank), or of levee protection and drainage. All protected land behind the levees but not included in drainage districts is subject to State, county general, special school and road (if within a special district), and levee taxes. Such lands within a drainage district are subject to the drainage district tax, in addition to all the above taxes. The one exception to this condition is found in Coahoma County, where one drainage district lies on the batture; here land is subject to State, county general, and drainage taxes.

It will be noted that the tax on batture land, other than in the drainage district in Coahoma County, ranges from 4½ to 7¢ per acre. Although the batture comprises only a small percentage of the total available hardwood timber land in the Delta, it contains a substantial percentage of the better grade merchantable hardwood timber. The important, if not the major, reason for this condition is the low tax on the land, making it financially profitable to hold this timber until it has attained a large size. Even when the tax on standing timber is added (generally 18 to 28¢ per acre on well-stocked stands of merchantable timber, but nothing on unmerchantable stands) the total tax (land and timber) is no greater than the average bare land tax on forest land in other locations.

The average tax on forest land in levee districts but outside drainage districts ranges from 13 to 26¢ per acre, while on such land within drainage districts it ranges from 23 to 67¢. Mention has been made previously of the method of equalizing the tax per acre between lands inside and outside drainage districts in Tunica County. As shown in table 4, the difference in tax is only 1.1¢ per acre in the county, whereas in other counties this difference is 37 to 54¢.

The distribution of the forest land in the sample by tax per acre and by location is shown in table 5. Batture land is included in the "forest land not in drainage districts," and the areas so located are indicated by a footnote. None of the samples studied in Issaquena County fell within that county's one drainage district. One feature of this distribution is the much wider spread in tax per acre within drainage districts than outside them. There are, of course, more tax-per-acre classes in the distribution in drainage districts, but also the area is much more evenly distributed among all classes. This condition arises chiefly through the wide variation in drainage benefit assessments, and in the rates of levy upon these benefits, among the large number of districts involved. Contributing factors are the differences in assessed values and in tax rates among the counties.

Table 4.- Area of forest land[1] in sample and average tax per acre[2]

County	Batture land		All other land									Grand total	
			Subject only to ordinary ad valorem tax			Subject to both ad valorem and drainage taxes			Total				
	Area	Tax	Area	Portion of area	Tax	Area	Portion of area	Tax	Area	Portion of area	Av. tax	Area	Av. tax
	Acres	Cents	Acres	Percent	Cents	Acres	Percent	Cents	Acres	Percent	Cents	Acres	Cents
Tunica	7,040	7.1	7,736	43	21.5	10,223	57	22.6	17,959	100	22.1	24,999	17.9
Coahoma	[3] 12,653	[3] 9.2	1,946	100	24.1	0	0	0	1,946	100	24.1	14,599	11.2
Quitman	0	0	4,282	23	12.9	14,235	77	66.6	18,517	100	54.2	18,517	54.2
Washington	0	0	326	1	27.5	25,931	99	60.7	26,257	100	60.2	26,257	60.2
Issaquena	8,805	4.5	49,889	100	25.7	0	0	0	49,889	100	25.7	58,694	22.5
Total	28,498		64,179	56		50,389	44		114,568	100		143,066	

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[1] "Forest land" in this table and tables 5, 12, 13, 14, and 15 includes both "timbered" and "uncultivatable" land.

[2] Data derived from Land rolls and tax levy orders of county Boards of Supervisors.

[3] Of this total area, 1,159 acres are inside a batture drainage district. On the area within this district, the average tax per acre is 52.6¢ while on the area outside the district (11,494 acres) the average tax per acre is 4.8¢.

Table 5.- Acreage distribution of forest area in sample, by tax per acre, including all taxes to which each location-class is subject

A. Forest land not in drainage districts

Tax per acre	County											
	Tunica		Coahoma		Quitman		Washington		Issaquena		Total	
Dollars	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
0.01-.04	-	-	2/1,181	9	-	-	-	-	2/6,707	11	7,888	9
0.05-.09	1/8,235	56	2/10,313	76	41	1	-	-	2/1,422	2	20,011	22
0.10-.19	1,425	10	-	-	4,241	99	-	-	4/7,369	13	13,035	14
0.20-.29	5,112	34	1,946	15	-	-	326	100	43,196	74	50,580	55
0.30-.39	4	3/	-	-	-	-	-	-		-	4	3/
Total	14,776	100	13,440	100	4,282	100	326	100	58,694	100	91,518	100

B. Forest land in drainage districts

Tax per acre	County									
	Tunica		Coahoma		Quitman		Washington		Total	
Dollars	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
0.10-.19	4,893	48	-	-	599	4	-		5,492	11
0.20-.29	3,348	33	-	-	3.914	28	380	2	7,642	15
0.30-.39	1,297	13	-	-	521	4	[illegible],180	8	3,978	8
0.40-.49	680	6	2/560	48	1,200	8	[illegible],429	25	8,869	17
0.50-.59		-	2/400	35	1,320	9	2,967	12	4,68[illegible]	9
0.60-.69	5	3/	2/177	15	589	[illegible]	[illegible],21[illegible]	12	3,985	8
0.70-.79	-	-	2/22	2	956	7	[illegible],30[illegible]	21	6,280	12
0.80-.89	-				818	6	[illegible],989	19	5.807	11
0.90-.99	-	-			5[illegible]7	[illegible]	[illegible]10	3/	657	1
1.00-1.19	-	-	-		1,[illegible]75	12	[illegible]60	1	2,[illegible]35	4
1.20-1.39	-	-			1,651	12		-	1.651	[illegible]
1.40-1.59	-	-			345	2		-	345	1
Total	10,223	100	1,15[illegible]	100	1[illegible],23[illegible]	100	2[illegible],9[illegible]1	100	[illegible],546	100

1/ Of this area 7,040 acres is batture land.
2/ All batture land.
3/ Less than 0.5 percent.
4/ Of this area 676 acres is batture land.

Although practically 100 percent of the forest land outside drainage districts in the five counties is taxed less than 30¢ an acre, only 26 percent of the land within drainage districts is taxed as low, while 40 percent of the latter land is taxed more than twice as much, and 9 percent is taxed more than three times as much.

In all counties (except Issaquena, which has no drainage districts in the sample areas), the drainage tax on forest land comprises more than 50 percent of the total tax charge, the percents ranging from 54 in Tunica County to 90 in Coahoma County (table 6). The lower percentage in Tunica County is due to the practice of lowering ad valorem assessments for general governmental purposes on land in drainage districts (page 12), while the abnormally high percent in Coahoma County is the result of the location of the sample in a batture drainage district where the land was not subject to special school, road, and levee district taxes, and where it was assessed at a lower value per acre than the protected land in other counties. In some districts, however, where the debt burden is lighter, the drainage tax is about equal to the total ad valorem tax (state, county, school, and/or road taxes).

The fact that the drainage tax exceeds the combined total of all other property taxes to which forest land in the Delta is subject is further evidence of the paramount importance of this phase of taxation in the solution of the forest-tax problem.

The tax on standing timber varies, of course, with its location, i.e., whether on the batture or protected. Timber within a drainage district is not subject to the drainage tax, which is levied only on the land. While the drainage district laws (Chap. 107, 1930 Code) provide that all taxable real property within the district is subject to tax for amortization of district bonds, the Supreme Court of Mississippi has held that the law does not act "to prevent the removal of the timber at any time and for any purpose desired by the owner, and this, too, without any payment of the installments of assessments to become due on the land subsequent to the removal" (Matthews et al. vs. Panola-Quitman Drainage District. 130 So. 910).

The average assessed value of timber per M board feet in each county as a whole has been given on page 13. The average tax per M board feet of timber, by location classes within the sample in each county, is shown in the following tabulation:

County	Location	
	Batture	All other land
	Cents	Cents
Tunica	14	29
Coahoma	12½	no data
Quitman	—	4/ 41
Washington	no data	23
Issaquena	18½	34

4/ Based on only one property, assessed at $9.20 per M bd.ft.

Table 6.-Apportionment among taxing authorities of average tax per acre on forest land[1] in drainage districts - 1936

(sample properties only)

County		State	County general[2]	Special school [3]	Special Road[3]	Total ad valorem	Levee[4]	Drainage	Grand total	Basis area
					Cents					Acres
Tunica	- Tax	1.3	3.3	[5]0.1	3.0	7.7	2.8	12.2	22.7	10,223
	Percent	6	15	[6]	13	34	12	54	100	
Coahoma[7]	- Tax	1.6	3.4	-	-	5.0	-	47.5	52.5	1,159
	Percent	3	7	-	-	10	-	90	100	
Quitman	- Tax	2.2	4.7	1.2	4.0	12.1	2.9	51.7	66.7	14,235
	Percent	3	7	2	6	18	4	78	100	
Washington	- Tax	4.0	11.6	4.4	[8]	20.0	3.5	38.2	61.7	25,931
	Percent	6	19	7	-	32	6	62	100	

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[1] "Timbered" and "uncultivatable" land.

[2] Including county-wide general school and road levies.

[3] Special district levies only.

[4] Including both acreage and ad valorem taxes.

[5] Only a small portion of the total sample area lay in special school districts. This figure represents total special district taxes divided by total sample area.

[6] Less than 0.5 percent.

[7] All of the sample in Coahoma County lay in a batture drainage district and was not subject to special school, road, or levee district taxes. This location also accounts for the relatively low taxes for State and county purposes, since the batture properties are assessed at a lower value than protected properties.

[8] Washington County has no special road districts.

RELATIONSHIP BETWEEN DRAINAGE BENEFIT ASSESSMENT AND AD VALOREM ASSESSMENTS

The evidence (previously presented) that the drainage tax represented more than 50 percent of the total tax charge, led to an investigation of the relationship between the drainage benefit assessments and the ad valorem assessments of the same properties. Data were obtained as to (a) the drainage benefit assessment of each property in the sample that lay in a drainage district, (b) the assessed value as of 1936, and (c) that of the date of fixing of the drainage benefit assessment. Since the benefit assessment is fixed uniformly at a certain sum per acre for each tax-roll description, and since an analysis of such assessments indicated that no cognizance was taken of the presence or absence of improvements, the benefit assessment against each tract ("description") was prorated to each land-use class on an acreage basis, if the given tract contained two or more classes of use (e.g., "cultivatable" and "uncultivatable").

In connection with this study, it should be remembered that while the ratio of the assessed value for ad valorem purposes to the true or market value of property is theoretically 100 percent, it is generally recognized that in actual practice the assessment ratio varies from as low as 25 percent to as high as 150 percent. In general, the lower the true value, the higher is the assessment ratio.

With this background of knowledge, an analysis of the data in table 7 reveals the gross inequity of the benefit assessments, particularly on "uncultivatable" and "timbered" lands. On "cultivatable" land, for example, the benefit assessment, based on county averages, is 56 to 117 percent of the 1936 ad valorem assessments, averaging 67 percent for all four counties. On "uncultivatable" land, however, it is 344 to 1457 percent, averaging 622 percent; while on "timbered land" it is 234 to 810 percent, averaging 446 percent! When the benefit assessment, fixed once and for all when the district was organized, is compared with the assessed value for ad valorem purposes as of the same year in which the benefit was fixed, a slightly more logical picture is shown. In the case of each land-use class, the ratio of benefit assessment to assessed value is lower for the original assessed value than for the 1936 value. Even in this comparison, however, it is evident that "uncultivatable" and "timbered" lands are inequitably treated in respect to drainage benefit, since "cultivatable" land has an average ratio of only 52 percent, while uncultivatable land has a ratio of 332 percent, and timbered land one of 160 percent. Whatever might have been said for the reasonableness of these benefit assessments at the time they were made, it is clear that the anticipated benefits have not been realized.

These relationships are further emphasized by the range in relationship between the benefit assessments and 1936 assessed values for each land-use class of each county (table 8). These figures are even more concrete evidence of the lack of a sound basis for fixing drainage benefits, ad valorem assessments, or both. The very wide range of ratios in every use-class and in nearly every county (only one tract was included under "timbered" land in Washington County), and the absurd ratios shown as maxima on "uncultivatable" land, are proof that the benefit assessments have no consistent relation to either the assessed value or market value of the lands on which they are assessed, nor, indeed, to the actual monetary value of the benefits conferred by the drainage ditch.

Table 7.- Average relationships of drainage benefit assessments to assessed values[1]

Counties	Cultivatable land					Uncultivatable land					Timbered land				
	Average drainage benefit assessment per acre 2/	Average assessed value per acre		Ratio of benefit to assessed value		Average drainage benefit assessment per acre 2/	Average assessed value per acre		Ratio of benefit to assessed value		Average drainage benefit assessment per acre 2/	Average assessed value per acre		Ratio of benefit to assessed value	
		1936	Orig.3/	1936	Orig.		1936	Orig.3/	1936	Orig.		1936	Orig.3/	1936	Orig.
	dollars			percent		dollars			percent		dollars			percent	
Tunica	14.27	20.83	45.18	69	32	12.51	1.65	8.72	758	14[illegible]	3.95	1.69	8.92	234	44
Coahoma	13.69	21.00	4/	65	4/	14.53	2.03	4/	71[illegible]	4/	11.40	2.00	4/	570	4/
Quitman	29.96	25.58	37.91	117	79	39.93	2.74	11.15	1457	[illegible]	14.98	1.85	9.77	810	157
Washington	13.60	24.49	23.20	56	59	17.20	5.00	4.56	344	3[illegible]	22.38	5.00	6/	448	6/
Average 8/	15.89	23.80	5/30.58	67	5/52	22.69	3.65	5/6.83	622	5/332	15.28	3.43	7/9.55	445	7/160

[1] Based on all land in sample lying within drainage districts. See table 4 for areas. None of the sample properties lay within the one drainage district in Issaquena County. All data relate to the same properties. Data from county Land Rolls and drainage district benefit assessment rolls.

[2] These figures represent the weighted-average drainage-benefit assessment per acre for each class of land use. See text for discussion of method of fixing such assessments.

[3] These figures represent the weighted-average assessed value per acre of all land in each land-use class, as of the year in which the benefit assessment was fixed on said land. Since the benefits were assessed (i.e., since the districts were organized) in different years (1912 - 1927), these figures do not represent the value as of any given year, but are the average values as of date of benefit assessment, for the purpose of comparing the relationship between benefit assessments and corresponding assessed values of the same year. Drainage benefits are fixed once and for all at moment of assessment, whereas the ad valorem assessment may change biennially.

[4] Impossible to compute, owing to changes in area and ownership of these batture properties. Much of the original area has been lost through flood washing, and it was impossible to locate original properties on the 1925 tax roll (date of organization of this batture drainage (levee) district).

[5] Based on 3 counties only; Coahoma excluded.

[6] Land bearing timber was classified as "unimproved" in 1912 - 1918, the years when drainage districts in Washington County were being organized. All such land is included here under "uncultivatable."

[7] Based on two counties only (Tunica, Quitman).

[8] Weighted average of all properties in sample in all four counties.

Table 8.- Ranges in relationship of benefit assessments to assessed values - 1936[1]

County	Cultivatable land	Uncultivatable land	Timbered land
	Percent		
Tunica	7 - 183	53 - 2,013	100 - 362
Coahoma	64 - 66	540 - 1,326	488 - 666
Quitman	6 - 315	108 - 4,501	- 810 -
Washington	11 - 150	48 - 600	376 - 600
All four counties	6 - 315	48 - 4,501	100 - 810

[1] These data represent the individual properties, within each land-use class, which had the highest and lowest ratios, respectively, of benefit assessment to assessed value as of 1936. For average ratios, see table 7.

The lack of any consistent relation between benefit assessments and assessed values is of particular moment in respect to "uncultivatable" and "timbered" lands. In the enabling acts under which the drainage districts were organized, their purposes are declared to be strictly "agricultural" and "for promotion of the public health" (Sec. 2, Chap. 269, Laws 1914). These purposes have been repeatedly reaffirmed by the courts, and in at least the one case previously cited (130 So. 910), the Supreme Court of the State called particular attention to the impossibility of agricultural use on lands covered with timber. While the Court held in this case that the timber itself could be removed, it has as rigidly held in other cases, and in obvious accord with the law, that the drainage district lien attaches to all land in the district, whether the same be in agricultural or forest use or be unused for any purpose. It is also recognized that land which will remain in forest use is benefited to a minor degree by the drainage improvements. Nevertheless, the data presented as to the relation of the drainage benefit assessment to ad valorem assessment on uncultivated lands, and the common knowledge that no direct benefit even remotely approaching in value the assessment imposed on such lands is conferred by draining them (except the few areas of once cleared and cropped land now abandoned because of recurrent overflows), indicate very clearly that the present system and method of drainage-district taxation is grossly inequitable, unjust, and in many cases, confiscatory when applied to forest land. It is, unquestionably, one, if not the chief, cause of the concentration of tax-forfeited forest land in Delta drainage districts.

TAX DELINQUENCY OF FOREST LAND

Law and procedure relating to delinquency

The general procedure in tax delinquency in Mississippi is very similar to that in other Southern States. Taxes unpaid on the final delinquency date are subject to penalty, and if the first installment be unpaid by the first Monday in April of the year following imposition, or if the second or third installment be unpaid by the third Monday in September, the land (or other property) on which they were levied is subject to sale at public auction by the county sheriff. If no bid at least equal to the taxes, penalty, and costs due is received, the property is "struck off" to the State. The redemption period, originally 2 years following the sheriff's sale was, in 1934, extended by the Legislature to 3 years, for the delinquencies of 1931 and 1932 taxes only. If the land is not redeemed prior to expiration of the redemption period, title vests in fee in the State, and the State Land Commissioner, with the approval of the Governor, can thereafter sell the land at a price not less than the taxes for which the land sold, plus costs and damages. Right of purchase under patent title extends to the original owner; indeed, in recent practice, was limited to him, his heirs, or assigns (4, p. 8). Owing to allegations made by a legislative committee investigating the Land Commissioner's Office, and counter-charges filed by the Commissioner, the Governor ordered a suspension of issuance of all patents, effective Nov. 17, 1936. This suspension is still in effect.

Extent of delinquency, 1936 - 1937

Area of, and taxes on, all lands within the sample which were recorded as in State title through forfeiture for taxes on Jan. 1, 1936, were obtained, and similar data on all land maturing in State title during 1936, and on all patents issued between Jan. 1, 1936 and Apr. 1, 1937. (A few special patents were issued after date of suspension noted above - Nov. 17, 1936.) Since the 1937 sale of taxes was not held until after Apr. 1, table 9 does not include data on forfeitures maturing at the time of that sale. So little land in Coahoma County was tax-forfeited that this county was not included in this phase of the study.

The data in table 9 show the decline in tax-forfeited acreage in the 15-month period, by land-use classes, and the relative proportion of the total forfeited area in each use class. It is of interest to note that not only did cultivatable land comprise the smallest percentage of the total forfeited area in both 1936 and 1937, but also, in all counties except Issaquena, where it remained constant, the percentage declined during this period. On the other hand, in all counties except Washington, the percentage which uncultivatable land formed of the total respective areas increased during the same period. While no timbered land was forfeited to State title in Quitman and Washington Counties, the percentage which this class formed of the total respective forfeited areas in Tunica and Issaquena Counties also increased.

Table 9.- Change in area of tax delinquent lands in State title--Jan. 1, 1936 to Apr. 1, 1937[1]

(selected townships only)

County	Cultivatable land [2]		Uncultivatable land [2]		Timbered land [2]		Unknown use [3]		Total		Net change in total area [4]
	1936	1937	1936	1937	1936	1937	1936	1937	1936	1937	
Tunica (acres)	293	217	11,179	10,608	635	635	3,130	2,062	15,237	13,522	-1,715
(percent)	1.9	1.6	73.5	78.4	4.2	4.7	20.5	15.2	100.0	100.0	- 11.3
Quitman (acres)	369	102	21,633	18,282	0	0	1,200	1,090	23,202	19,474	-3,728
(percent)	1.6	0.5	93.2	93.9	0.0	0.0	5.2	5.6	100.0	100.0	- 16.1
Washington (acres)	536	20	12,390	2,420	0	0	280	160	[5] 13,206	[6] 2,600	-10,606
(percent)	4.1	0.8	93.8	93.1	0.0	0.0	2.1	6.1	100.0	100.0	- 80.3
Issaquena (acres)	1,268	1,561	19,012	23,610	4,443	5,644	1,617	1,457	26,340	32,272	+5,932
(percent)	4.8	4.8	72.2	73.2	16.9	17.5	6.1	4.5	100.0	100.0	+ 22.5
Total (acres)	2,466	1,900	64,214	54,920	5,078	6,279	6,227	4,769	77,985	67,868	10,117
(percent) - 1936	3.2		82.3		6.5		8.0		100.0		
(percent) - 1937		2.8		80.9		9.3		7.0		100.0	-13.0

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[1] Data from "Lists of Lands Sold to State," "Abstracts of Titles," and "Land Roll - 1936-37." Coahoma County had so little land in State title that it was omitted in this phase of the study.

[2] Classification according to Land Roll as of year of original delinquency. No subsequent classification data are available.

[3] The tracts included here could not be definitely located or classified as to use as of year of original delinquency.

[4] Difference between total areas in State title as of Jan. 1, 1936, and Apr. 1, 1937, in acres and in percentage of change.

[5] Includes 172 acres listed as in State title on Jan. 1, 1936, but later found to be in Federal title (unappropriated public domain).

[6] Does not include area transferred to jurisdiction of Mississippi Agricultural Experiment Station.

The reason for this condition is obvious. The year 1936 was the best cotton year in the Delta in many years, with a bumper crop and a good price. Hence farm income was at a high level, and advantage of the situation was taken to purchase additional "cultivatable" land and better grade "uncultivatable" (or more accurately, uncultivated) land in order to increase production in 1937. This is not the place to discuss the wisdom or results (now evident in both crop reports and current prices) of such increased cotton production. In driving through the country it was clearly evident that many areas never before put to the plow were being cleared for cotton crops. This one factor accounts for a major part of the reduction in tax-forfeited acreage in the sample, and, presumably, in the Delta counties as a whole. For this reason, the reduction may be temporary.

The same forces, however, which caused high tax-forfeiture of forest land in the past continued to operate during this 15-month period to effect an increase in current forfeiture of this class of land in nearly all counties. Washington is an apparent exception, but much of the so-called "uncultivatable" land in this county, and to a less extent in all counties, is actually cultivatable at a profit when cotton reaches a price of 12 to 15¢ a pound. The current net increase in forfeited forest area in Issaquena County, which is primarily a forest county, is evidence that true forest land continued to be forfeited even when non-forest land was being purchased under patent from the State.

Trends in delinquency

It is also of interest to know the year of origin of the delinquency of land in State title as of Jan. 1, 1936 (table 10). Taking all four counties together, the effect of the depression is evident; 58 percent of the total forfeited area was derived from tax sales held subsequent to 1929. That the depression was not the only cause of tax distress, however, is shown by the fact that 42 percent of the total forfeiture accrued during the years of "prosperity" — 1925 to 1929. Variation among counties was wide, moreover, and no clear inferences as to the causes of delinquency can be drawn from these data. As indicated above, the periodicity of "feast and famine" that characterizes cotton growing may well account for the fluctuation in extent of forfeiture. It should be remembered, also, that the high percentage of total forfeiture represented by land sold in 1932 for 1931 taxes and maturing in State title in 1935, involved, as of Jan. 1, 1936, land which had been in State title, subject to sale, for only a few months, whereas the residue in State title derived from earlier sales had been forfeited and subject to sale for $1\frac{1}{2}$ to 12 or more years.

Taxes for which land was forfeited

In order to evaluate the respective effects of the advalorem and drainage taxes, data were obtained on the taxes on each tract of land forfeited during 1925 to 1932, as of the last year prior to its delinquency. These date were then averaged by years to arrive at an average ad valorem and average drainage tax per acre per year in each county (table 11). It should be noted that the years shown are the years of levy, not the years of tax sale. The data for 1932 taxes (land sold in 1933 and matured in 1936) have been added in this table, but do not appear in tables 8 and 9. The Washington County records for 1925 and 1926 show only the total tax charge, including ad valorem and drainage levies. In Issaquena County, none of the sample fell within that county's one drainage district.

Table 10.- Area in State title as of Jan. 1, 1936, by year of original tax sale

(selected townships only)

County		Year of sheriff's tax sale 1/								Totals
		1925 or prior	1926	1927	1928	1929	1930	1931	1932	
Tunica	(acres)	1,890	0	0	1,360	4,183	1,440	1,479	4,885	15,237
	(percent)	12	0	0	9	28	9	10	32	100
Quitman	(acres)	1,960	2,260	7,692	488	1,562	401	6,446	2,393	23,202
	(percent)	8	10	33	2	7	2	28	10	100
Washington	(acres)	2,244	4,002	240	0	0	0	120	6,600	13,206
	(percent)	17	30	2	0	0	0	1	50	100
Issaquena	(acres)	413	0	0	0	5,028	126	16,254	4,519	26,340
	(percent)	2	0	0	0	19	2/	62	17	100
Total	(acres)	6,507	6,262	7,932	1,848	10,773	1,967	24,299	18,397	77,985
	(percent)	8	8	10	2	14	3	31	24	100

1/ Property is "sold" to State at public auction by the county sheriff, on failure of any private person to bid amount of taxes and penalty due, at sale held 1 year after date of imposition of tax levy. For example, 1932 sale (last column) was for 1931 taxes. Title is certified to State 2 (or 3) years subsequent to tax sale. Titles forfeited for 1932 taxes, however, did not mature in State until April (or Sept.) 1936, owing to extension of redemption period. These data are from County Land Rolls.

2/ Less than 0.5 percent.

Table 11. - Area of, and average tax per acre on, forfeited rural land, levied in year prior to year of forfeiture; years of levy — 1925 to 1932 1/ (selected townships only)

Item	Year	Counties			
		Tunica	Quitman	Washington	Issaquena
Area in acres	1925	0	2,260	4,002	0
Ad valorem 2/		-	$0.69	3/	-
Drainage		-	0.91	3/	-
Total		-	1.60	$1.46	-
Area in acres	1926	0	7,692	240	0
Ad valorem 2/		-	$0.46	3/	-
Drainage		-	1.89	3/	-
Total		-	2.35	$2.18	-
Area in acres	1927	1,360	488	0	0
Ad valorem 2/		3/	$0.32	-	-
Drainage		3/	1.85	-	-
Total		3/	2.17	-	-
Area in acres	1928	4,183	1,562	0	5,028
Ad valorem 2/		$0.42	$0.42	-	$0.20
Drainage		1.13	0.89	-	0
Total		1.55	1.31	-	0.20
Area in acres	1929	1,440	401	0	126
Ad valorem 2/		$0.46	3/	-	$0.36
Drainage		0.96	3/	-	0
Total		1.42	3/	-	0.36
Area in acres	1930	1,479	6,446	120	4/14,974
Ad valorem 2/		$0.34	$0.40	$0.29	$0.24
Drainage		0.31	1.02	1.15	0
Total		0.65	1.42	1.44	0.24
Area in acres	1931	4,885	2,393	6,600	5/ 4,439
Ad valorem 2/		$0.24	$0.70	$0.40	$0.24
Drainage		0.69	0.48	1.20	0
Total		0.93	1.18	1.60	0.24
Area in acres	1932	5,069	1,225	3,043	12,281
Ad valorem 2/		$0.13	$0.35	3/	$0.18
Drainage		1.00	0.85	3/	0
Total		1.13	1.20	3/	0.18

1/ The year of forfeiture is 1 year subsequent to year of levy. Data for years prior to 1925 are not computed, owing to lack of adequate tax data. These data are from Land Rolls of each indicated year of levy, and from "List of Lands Sold to State" for each year of forfeiture.
2/ Includes levee ad valorem and levee acreage tax.
3/ Tax data not available.
4/ Tax data on 1,280 acres missing.
5/ Tax data on 80 acres missing.

It will be noted that with but two exceptions (Tunica County - 1930; Quitman County - 1931), the drainage tax exceeds the ad valorem tax by percentages ranging from a minimum of 32 (Quitman County - 1925) to a maximum of 669 (Tunica County - 1932). Hence, it is obvious that the drainage tax is a major factor in the inability of these lands to produce sufficient revenue to meet tax payments.

The total average tax charge is also of interest, varying, on lands in drainage districts, from a minimum of 65¢ per acre (Tunica County - 1930) to a maximum of $2.35 per acre (Quitman County - 1926). The lands here involved include, of course, all classes of use — good cultivated land as well as cut-over forest land. It is extremely unlikely, however, that the best crop land or the best timbered land is included in this forfeited acreage. Such lands, while they may occasionally be involved in temporary delinquency, do not remain long in State title.

No definite trends over this period toward a lower total tax are shown by the data in table 11. In Quitman County there is an irregular trend downward, but in other counties the trend is too irregular, and the data too meager, for any significant deductions to be drawn.

The data in tables 12 to 15 show, for each county, the distribution of the forfeited forest area, classified by total tax per acre, levied in the year prior to year of forfeiture — again, the taxes for which the property was allowed to forfeit to the State. In Tunica County (table 12) and Quitman County (table 13) the spread of tax classes is wider than in Washington or Issaquena Counties (tables 14 and 15, respectively). These tables are self-explanatory and, in the case of the first three counties, point in the same direction It is obvious that even high-quality forest land cannot pay an annual tax of $1 to $3 per acre and still produce enough timber at current or expected prices to show a net profit. Yet in Quitman County, over the 8-year period, 81 percent of the forest area in State title as of Jan. 1, 1936, or matured in State during 1936, was taxed at the rate of $1 or more per acre per year. In Tunica County, 64 percent of the same base was so taxed, and in Washington County 97 percent! The wonder is not that so much forest land is forfeited, but that so little is in this condition. Analysis of the location of tax-forfeited lands shows, moreover, that in Tunica, Quitman, and Washington Counties, the greater portion of the lands that have been forfeited lie within drainage districts. A contributing factor in southeastern Quitman County is the large percentage of tree species of low or negligible commercial value found in the forest stands.

Issaquena County (table 15) is not, so far as the sample is concerned, under the burden of drainage taxes. Hence, all forest land which had been forfeited for taxes was taxed less than 60¢ an acre, and 76 percent of the area was taxed less than 20¢ an acre. Nevertheless, this county has more tax-forfeited land than any other county in the Delta. Undoubtedly, the cause here is not drainage taxes, but rather the low quality of the forest land. This low quality is the result of (1) overcutting the timber resources without any attempt at conservation, and (2) the presence of low-grade tree species over much of the forest area of the county, which lies in the Yazoo Backwater Area and is subject to annual inundation by floodwaters of the Mississippi.

Table 12. - Distribution of tax-forfeited forest area, classified by total tax per acre, levied in year prior to forfeiture; years of levy — 1928 to 1932[1]

Tunica county

Tax per acre	Year of levy						Percent
	1928	1929	1930	1931	1932	Total	1928 - 1932
				Acres			
$0.01 - .19	-	-	-	-	350	350	2
$0.20 - .39	-	-	80	478	41	599	4
$0.40 - .59	-	-	72	263	-	335	2
$0.60 - .79	-	-	454	1,930	160	2,544	15
$0.80 - .99	433	30	-	760	892	2,115	13
$1.00 - 1.19	478	218	688	110	1,129	2,623	16
$1.20 - 1.39	1,114	344	-	1,070	1,131	3,659	22
$1.40 - 1.59	865	440	40	166	1,002	2,513	15
$1.60 - 1.79	391	76	45	109	22	643	4
$1.80 - 1.99	-	-	-	28	-	28	[2]
$2.00 - 2.29	700	200	41	-	-	941	6
$2.30 - 2.99	-	-	-	-	-	-	-
$3.00 and up	120	-	-	-	-	120	1

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[1] Data from "List of Lands Sold to State" for each year of forfeiture (1 year subsequent to indicated years of levy).

[2] Less than 0.5 percent.

Table 13. - Distribution of tax-forfeited forest area, classified by total tax per acre, levied in year prior to forfeiture; years of levy - 1925 to 1932[1]

Quitman County

Tax per acre	Year of levy								Percent of total for 1925 - 1932
	1925	1926	1927	1928	1930	1931	1932	Total	
	Acres								
$0.01 - .19	-	400	-	-	-	-	40	440	2
$0.20 - .39	-	-	-	-	-	540	89	629	3
$0.40 - .59	-	400	-	-	959	356	-	1,715	8
$0.60 - .79	-	-	-		200	-	118	318	2
$0.80 - .99	-	-	-	922		-	-	922	4
$1.00 - 1.19	-		-	-	80	256	709	1,045	5
$1.20 - 1.39	-	-		-	290	385	40	715	3
$1.40 - 1.59	340	466	-	-	2,663	558	-	4,027	19
$1.60 - 1.79	1,620	160	-	-	1,280	20	-	3,080	15
$1.80 - 1.99	-		-	480	874	16	-	1,370	7
$2.00 - 2.29	-	800	488	160	-	-	-	1,448	7
$2.30 - 2.59	-	2,555	-	-	-	-	-	2,555	12
$2.60 - 2.99	80	2,311	-	-				2,391	11
$3.00 and up	-	480			-		-	480	2

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[1] Data from "List of Lands Sold to State" for each year of forfeiture (1 year subsequent to indicated years of levy).

Table 14. - Distribution of tax-forfeited forest area, classified by total tax per acre, levied in year prior to forfeiture: years of levy—1924 (or earlier) to 1931[1]

Washington County

Tax per acre	Year of levy							Percent of total 1924 or earlier to 1931
	1924 and earlier	1925	1926	1927-29	1930	1931	Total	
	Acres							
$0.01 - .19	-	-	-	-	-	-	-	-
$0.20 - .39	-	-	-	-	-	20	20	2/
$0.40 - .59	-	-	-	-	-	40	40	2/
$0.60 - .79	-	-	-	-	-	209	209	2
$0.80 - .99	-	-	-		80	-	80	1
$1.00 - 1.19	-	-	-	-	-	212	212	2
$1.20 - 1.39	820	498		-		-	1,318	12
$1.40 - 1.59	160	1,236	-	-	-	4,988	6,384	57
$1.60 - 1.79	252	1,205	-	-	-	-	1,457	13
$1.80 - 1.99	-	-		-	-	80	80	1
$2.00 - 2.29	120	-	160	-	-	-	280	3
$2.30 - 2.59	400	-	60	-		600	1,060	9
$2.60 - 2.99	-	-	-	-	40		40	2/

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[1] These data from "List of Lands Sold to State" for each year of forfeiture (1 year subsequent to indicated years of levy). No data available for 1932.

2/ Less than 0.5 percent.

Table 15. - Distribution of tax-forfeited forest area, classified by ad valorem[1] tax per acre, levied in year prior to forfeiture; years of levy — 1928 to 1932[2]

Issaquena County

Year of levy	$0.01 - .19	$0.20 - .39	$0.40 - .59
	Acres		
1928	4,178	356	-
1929	91	-	-
1930	7,750	6,468	-
1931	2,242	1,221	69
1932	11,398	-	-
Total	25,659	8,045	69
Percent 1928-1932	76	24	[3]

[1] No properties in townships selected in this county were subject to drainage taxes.

[2] Data from "List of Lands sold to State" for each year of forfeiture (1 year subsequent to indicated years of levy).

[3] Less than 0.5 percent.

Relation of forest land delinquency to total delinquency

One very significant fact shown by the analysis of these delinquency data is that 83 percent of the sample area in the four counties in State title as of Jan. 1, 1936, plus that matured in the State during 1936 (including that portion of the latter which was patented during 1936), was forest land. The division by counties was as follows:

County	Total area forfeited in sample	Forest area forfeited in sample	Proportion forest area is of total
	Acres		Percent
Tunica	20,306	16,470	81
Quitman	24,427	21,135	87
Washington	16,249	11,180	69
Issaquena	38,621	33,773	87
Totals	99,603	82,558	83

This distribution of forfeited forested area among counties is logical in view of the relation of the total forest area of each county to the total land area of each. Washington has the smallest percentage of its gross area in forest, and Quitman and Issaquena the largest percentage. This relation accords with the fact that forest land is far more seriously involved in delinquency than crop land, for the reasons previously discussed.

Original and patentee ownership of forfeited land

In order to appraise the changes in ownership resulting from patenting of tax-forfeited lands, data were obtained on the nature of the business or livelihood of both the original owner of such land and the patentee (table 16). These data show very definite tendencies away from corporate forest ownership and toward individual farm ownership, even in the short space of time covered by the data (in general, from not earlier than 1925 to date). The intermediate "owner" in all cases, of course, was the State of Mississippi.

Taking all four counties as a unit, since the same tendency is found in each, it is shown that while 17 3/4 percent of the patented area was originally owned by farmers, 60 3/4 percent of that area was patented by farmers. Similarly, while 46 percent was owned originally by lumber companies, less than 1 percent was patented by such corporations. Land speculators continued to control almost exactly the same acreage and the same percentage of the total area as they did originally. Other miscellaneous types of owners decreased their holdings from 8½ percent to 2 3/4 percent of the total. Through foreclosure of drainage tax liens and subsequent patents from the State, drainage districts came into control of 8-1/3 percent of the total patented area. In most cases, however, the records show that the district later disposed of these lands to private individuals.

One significant feature of the disposition of forfeited land is the fact that nearly 19 percent of the total patented area in the four counties was purchased by the original owner, his heirs, or assigns. This was noticeably the case in Issaquena County, in which 34 percent of the patented area was so purchased.

So far as forest land is concerned, the tendencies in ownership shown above for all rural land are not very clear. Forest land, other than that which can be put into farm crops and cultivated at a profit, has not been extensively patented. Where it has been, it is now being cleared and will be put into cotton — with what results remain to be seen. Hence the real problem of tax-forfeiture of forest land has not been met by the patenting of 12,171 acres of lumber-company holdings by farmers or other individuals who plan to convert it, at least temporarily, into crop land. If any tract of forest land is better suited for agricultural crop production than for forest crops, then, of course, it should be put to the higher use, but many thousands of acres of forest land in the Delta not suited for agricultural crops are incapable of producing forest crops at a profit to their owners under the present tax structure. Such land continues as a new and fruitless public domain, generally unprotected and constantly deteriorating; it remains a burden on local government and taxpayers, since it returns no revenue and hence tends either to increase the tax burden on remaining land or to force curtailment of public services.

Table 16.- Changes in ownership of all rural tax-forfeited and subsequently patented land for counties[1]

(Selected townships only)

Type of ownership		Tunica	Quitman	Washington	Issaquena	Total	Ratio of each class to total
From[2]	To[3]						
		acres[4]					percent
Farmer	Farmer	1,073	415	1,382	296	3,166	12.0
	Land Speculator	238	0	172	480	890	3.4
	Drainage Dist.	0	567	0	0	567	2.1
	Other	0	78	0	0	78	0.3
	Total	1,311	1,060	1,554	776	4,701	17.8
Lumber Co.	Lumber Co.	0	0	161	0	161	0.6
	Farmer	2,419	1,200	4,370	1,688	9,677	36.6
	Land Speculator	0	0	0	1,240	1,240	4.7
	Drainage Dist.	0	717	0	0	717	2.7
	Other	0	16	320	40	376	1.4
	Total	2,419	1,933	4,851	2,968	12,171	46.0
Land Speculator	Land Speculator	200	0	0	0	200	0.7
	Farmer	240	160	720	440	1,560	5.9
	Drainage Dist.	0	420	0	0	420	1.6
	Other	0	0	163	0	163	0.6
	Total	440	580	6/ 883	440	8/ 2,343	8.8
Other	Other	0	0	0	97	97	0.4
	Farmer	968	110	257	316	1,651	6.2
	Land Speculator	0	0	0	10	10	9/
	Drainage Dist.	0	503	0	0	503	1.9
	Total	968	613	257	423	2,261	8.5
All classes	Farmer	4,700	1,885	6,729	2,740	16,054	60.7
	Lumber Co.	0	0	161	0	161	0.6
	Land Speculator	438	0	172	1,730	2,340	8.8
	Drainage Dist.	0	2,207	0	0	2,207	8.3
	Other	0	94	483	137	714	2.7
	Total	5,138	4,186	7/10,214	4,607	8/21,476	81.1
Original owner same or heirs[5]		1,685	757	160	2,395	4,997	18.9
Grand Total		6,823	4,943	10,374	7,002	8/26,473	100.0

1/ Data from Land Roll for 1936-37, lists of lands sold to State, and abstracts of titles.
2/ Type of ownership represented by original owner.
3/ Type of ownership represented by patentee.
4/ Acreage patented, of that in State title as of Jan. 1, 1936, and that maturing in State during 1936, as of April 1, 1937.
5/ Acreage patented by original owner or his heirs or assignes.
6/ In addition to the acreage here shown, 2,669 acres, originally owned by a land speculating company and matured in the State, was transferred to the jurisdiction of the Miss. State Agric. Exp. Sta.
7/ Includes the 2,669 acres noted in 6/.
8/ Excludes the 2,669 acres noted in 6/.
9/ Less than 0.05 percent.

TAX PER ACRE ON FOREST LAND IN RELATION TO ITS INCOME-PRODUCING CAPACITY

The weight of forest-land taxes in the Yazoo Delta having been shown by absolute amounts and in relation to tax delinquency, it is now in order to consider it in relation to the income-producing capacity of the forest land, as measured by the return on an investment at current prices and under present costs and risks. This can be done best by attempting to estimate a "reasonable" tax per acre under these conditions, and by comparing this tax with the actual levies. While the values used in the following discussion are only approximate, they represent the best available current estimates.

The average selling price of Delta land considered useful chiefly for growing forests, and stocked with inferior trees left after cutting and with second growth, is $8 per acre. This does not include forest land speculatively valuable for higher uses, such as cotton production, since this land commands higher prices. To avoid any danger of understating the tax charge, a tax rate of 3 percent is assumed — a rate at least double the average nation-wide rate for combined State and local tax purposes — in which case the tax on $8 land would be 24¢. To the tax charge must be added the annual costs of protection and administration borne by the landowner, here estimated at 4¢ per acre. Based on the net growth rate of commercial timber expected from existing inadequately stocked stands under adequate fire protection and simple but sound management (150 board feet plus 1/3 cord per acre per year for the forests of the Delta as a whole), and on current stumpage prices, and with addition of an allowance for income from incidental grazing, it is estimated that the annual gross income per acre would be 80¢. Deducting taxes and other costs (24¢ + 4¢ = 28¢) from this income would leave a net income of 52¢ per acre, or a return of 6.5 percent on the investment. This is a reasonable return, leaving a small margin for risk.5/

The tax per acre in the foregoing calculation (24¢) is not only based on what would ordinarily be considered a maximum rate, but any higher tax rate would reduce the rate of return on the investment below what reasonably might be expected. This determination of a "reasonable" tax is not intended to indicate either the actual or the correct method of distributing the ad valorem tax burden. It does provide, however, a reasonable basis for comparing the actual taxes per acre paid in the Delta (table 4) with a tax which, under present conditions, is the highest that would permit the earning of a moderate rate of return on present investments. In order to make this comparison intelligently, it is necessary to consider separately forest lands according to their location, i.e., whether (1) inside drainage districts, (2) outside drainage districts, or (3) on batture lands.

5/ On forest land with a speculative value of $10 per acre, and with the same returns, costs, and tax rate, the return would be 4.6 percent on the market value and 5.75 percent on the $8 forest investment value; on land with a speculative value of $15 per acre, the return would be only 2.07 percent on market, and 3.87 percent on forest-investment, value. Logically, the return from timber growing should be computed on the value that the land has for forestry purposes only; any additional margin of speculative value should look for its return out of the anticipated future productivity in some other use.

(1) Inside drainage districts, the present average tax on forest land in both Quitman and Washington Counties is over two and a half times the estimated "reasonable" tax of 24¢ per acre. On the other hand, in Tunica County the tax on similar land is slightly lower than 24¢ per acre. If the tax on timber is included in the tax on forest land, however, the resulting total tax in the first two counties is four and a half times the estimated "reasonable" tax. (Timber, as such, is not subject to drainage tax.) In Tunica, the total tax on land and timber would be nearly three times this estimated tax. Assuming that the forest stand is equal to the present average stand determined by the Forest Survey (1,500 board feet per acre), the tax on timber alone (assuming this volume to be actually assessed) averages about 43¢ per acre. (See page 13 for average tax per M bd. ft. by counties and location.)

(2) Outside of drainage districts, this "reasonable" tax on land and timber relative to the present average tax on forest land, exclusive of timber assessed as such, is higher in three counties, equal in one county, and lower in one county. If the tax on timber is added to that on forest land, the estimated "reasonable" tax is lower in all counties than the present average tax.

(3) On batture land the data show that, assuming an "average" stand of 1500 board feet per acre, the present tax on land and timber is 4 to 8¢ per acre more than the estimated "reasonable" tax in Tunica and Issaquena Counties, while in Coahoma County it is equal to that tax.

It is realized, of course, that these comparisons, being based on gross averages, are suggestive rather than conclusive, but they point to the source of the difficulty where the problem of forest land and timber taxation is most acute. These data show that the average forest stand in the Delta, whether located in a drainage district or outside it, unless it be on batture land, is not producing sufficient annual income to meet the present annual taxes on land and timber, and also yield a reasonable rate of return on the investment in the property. To be sure, this conclusion is based on the assumption that the full volume of merchantable timber present is assessed as such. If only a half or a third (or none) of it appears on the tax roll, then — assuming timber is present but that the land lies outside of a drainage district — the actual tax on the land and such volume of timber as is assessed would perhaps be no more than the 24¢ per acre that has been used in these calculations. Insofar as cut-over land is concerned, no matter where located (except on the batture), it is evident that the land tax now imposed (exclusive of tax on timber assessed as such) is too high to permit profitable retention of such land in private ownership, unless undeveloped agricultural or other values are present.

Hence it appears, on the basis of facts presented in this report, that a prerequisite of successful private forestry in the Yazoo Delta is a revision downward of the total tax charge now imposed on forest land and timber. The possibilities of such revision will be explored in the following section.

Outlook for the future in respect to drainage taxes

This report has emphasized repeatedly the fact that drainage taxes on forest land have been, and still are in many districts, so high in relation to the income-producing capacity that they have caused excessive forfeiture of titles through their non-payment, and have acted as a serious obstacle to the private practice of forestry. Any consideration of the future of forestry in the Delta must deal, first and foremost, with the outlook in respect to drainage taxes.

In connection with this study, data were obtained on the current financial status and past history of each drainage district in the five counties. With a few exceptions, generally in the smaller districts, this survey revealed a financial history strewn with defaulted debt payments, refinancings, and continual balancing on the brink of bankruptcy, with frequent slips over the edge. Overexpansion of operations, excessive overcapitalization, and in some cases, grievous lack of good business management and judgment, all contributed to the sorry picture. Districts, created in a completely haphazard relation to already existing ones and pyramided one on top of another, have floated bond issues from the proceeds of which no worthwhile construction has resulted; and in some cases, after having incurred initial debts, they have been dissolved by the courts, leaving the residents of the district the unpleasant task of paying off their debts for no material gain whatsoever.

This condition had become so serious by 1933-34 that most districts were in, or on the verge of, complete bankruptcy. Those with sufficient taxable assets in the form of real estate subject to drainage taxes were able to refinance their bonded indebtedness through agreement with their bondholders and the Reconstruction Finance Corporation. Settlement was made at percentages of total debt ranging from 15 to 90, averaging, perhaps, around 50 percent. The R.F.C. became the only bondholder, and all district refunding bonds so issued were 33-year serial 4-percent bonds, representing a general reduction in interest rate of 1½ to 2 percent. A few districts applied for reorganization and compromise of indebtedness under the Municipal Relief Act of May 24, 1934.6/ More recently, a few districts have taken advantage of an act authorizing them, after due notice of intent, to issue refunding bonds in anticipation of taxes authorized to be levied over the 25-year period subsequent to date of issue of such refunding bonds (Chapter 266, Laws of 1936).

As a result of this widespread refinancing, most operating districts were able to reduce their tax rates (i.e., the percentage levy on the benefit assessment) by 1 to 3 percent. In many districts at the present time the rate is only 1 to 2 percent, whereas it formerly ran from 1 to 5, or even 7, percent. This is, of course, a desirable move in the right direction,

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6/ U.S.Code, Title 11, Ch. 9 (ss. 301-303); declared unconstitutional by Supreme Court of the United States in Ashton vs. Cameron County (Tex.) Water Improvement District, 56 Sup. Ct. 892, 1936; reenacted after revision as U.S.Code, Title 11, Bankruptcy, Ch. 10, ss. 401-404, 1937.

but as has been shown in previous sections of this report, it is not adequate to a solution of the drainage-tax problem on forest land.

The most difficult problems to solve in any remedial program applied to the drainage districts are (1) the amortization of the large volume of outstanding bonds of each of the 110 districts in the Delta, through some process equitable to both bondholders and taxpayers, and (2) the legal and fiscal aspects of any plan that would consolidate or modify the districts, their benefit assessments, or their debts. The solution of numerous other problems, less difficult, perhaps, but none the less intricate, is also necessary to any sound and permanent improvement in the general situation.

The solution of the legal and fiscal questions is beyond the scope of this paper. In formulating a broad policy, however, two alternatives deserve consideration. The first possibility is to continue as at present, in the hope and expectation that a sufficient amount of drainage taxes will be paid to permit the meeting of principal and interest payments until the bonded debt has been amortized. This hope is more nearly realizable now than formerly in those districts (far from all of them) which have been recently refinanced by the Reconstruction Finance Corporation. Even in those districts, this procedure will, particularly on forest land, mean continued tax delinquency, chronic in many areas of low or medium productivity and occasional elsewhere in years of low income, as well as continued abuse of the soil and the natural resources. Constructive land management will be seriously hampered. For example, the continued pressure for highest possible immediate returns will tend to force all forest land capable of yielding any cotton into production of that crop, even though its abandonment in years of low prices for cotton would be virtually certain. An incidental feature would be either greatly increased expenditures by the State for protection of its equities in tax-forfeited forest lands, or the loss of these equities.

The alternative policy is to enact a sound legislative program designed to liquidate as rapidly as possible the outstanding obligations of the drainage districts by readjusting the drainage taxes on the basis of the benefit actually conferred on each property, rather than levying them on the fictitious and wholly indefensible basis now employed and previously discussed. Such a policy would, of course, be difficult to develop and carry out, but it is not impossible.[7] Possibly it should lead toward the establishment of one Delta-wide district, with centralized control of fiscal matters and future engineering developments. Undoubtedly it would envisage the abandonment of some projects not needed in a well-rounded drainage development, as well as the dissolution of the districts concerned as soon as their debts could be liquidated. Whatever provisions were found necessary, the development and carrying out of any such policy is a responsibility of the State, with such Federal aid, either advisory or monetary, as may be available and desirable.

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[7] In this connection, cf. Kilpatrick, Wylie. Federal Regulation of Local Debt. National Municipal Review 26 (6): 283-290, 298. New York. 1937.

Outlook for the future in respect to other taxes

The ad valorem and acreage taxes imposed by the two levee districts will presumably remain constant at about their present rates. These taxes, which rarely exceed a total of 4¢ per acre, are not burdensome on forest land.

Reductions in taxes for ordinary governmental purposes will be effected, if at all, by changes in the allocation of governmental functions and responsibilities not less than by improvements in local efficiency. As was stated previously, there is an increasing tendency toward abolition of local special road districts in favor of at least county-wide supervision. Under the State's expanding highway program, there is also a commendable tendency toward State supervision and control of the entire road system of the State, other than purely local roads. Such centralization, in most states where it has been put in operation, has effected a material saving in cost of road construction, maintenance, and financing, with consequent reduction in road taxes.

Similar and equally commendable tendencies are evident in the school district system, particularly in respect to the abolition of the numerous special districts in favor of one county-wide district. While complete State support of minimum educational service has not been tried in the South outside of North Carolina, there is much to be said for this measure. The evidence is certainly favorable to at least increased fiscal support of the county school systems by the State, with consequent savings through centralized purchasing, financing, and similar activities. Such savings would be immediately reflected in lowered school taxes.

Reorganization of county government and of State government, while desirable, is not within the purview of this report. A detailed study, with recommendations, covering these features has already been submitted to the Governor and Legislature by a qualified agency (1).

The immediately preceding discussion has centered on major changes in functions and centralization of government as an aid in tax reduction. These are necessary prerequisites of any permanent remedial program, but entail slow processes of enactment. Certain steps, however, can be taken without undue delay which, it is believed, will be of immediate benefit to timberland owners in lowering their taxes.

As has been stated, one ill effect of the present classification of land in Mississippi, as it is now made and operated for taxation purposes, is that it tends to "freeze" values at a uniform figure per class in each county or in several counties, irrespective of the factors affecting the true market value of each individual property. This condition arises from two obvious causes, both easily remedied if the people of the State really wish them corrected. First, the classification itself, as defined in the statutes, is not accurately made, nor can it be so made except on advice of trained agronomists, economists, and foresters. In a better statutory definition, present use would be the criterion, not potential adaptability. Even a clear and simple statutory classification would require, for its successful operation, the exercise of considerable care on the part of the assessor.

Secondly, if there be any point in classification for taxation purposes, as envisaged in the present Mississippi Code, it should result in the establishment of reasonable relationships in assessed values in line with the actual productivity of the different classes of land in each county. At present, the land is classified on the roll, but not in the assessor's mind, so far as individual properties are concerned. He tends, on the contrary, to do the easiest thing: to assess all land of each class—or even all land not in cultivation (with a few exceptions)—at the same figure throughout his entire county. Although differentiation is made in assessing crop land and batture land, almost every other tract, whether located on a paved highway or back in an overflow area, whether clear-cut and burned or bearing high-grade young timber, whether 40 acres or 400 acres in area, is assessed at the particular uniform value per acre set—in many cases by formal order of the Board of Supervisors—for that class in that county. No such system of assessment can ever achieve even approximate equity in taxation. Every tract of land should be assessed at 100 percent of its true market value, or at such other percentage of true value as the State may determine, taking into full consideration all the factors—including present use of each part, accessibility, condition, and ownership—which affect the true value, as would be done by an informed buyer and informed seller trading in the open market. Such assessment can be made properly only by trained assessors, adequately compensated, and free from the compulsion of political campaigns for election. If trained assessors were equipped with modern techniques of appraisal, no predetermined range of values for various classes of land would be needed or desirable.8/

Relation of taxation to future opportunities for private forestry

These general suggestions have been made without reference to their specific effect on forest taxation because they are fundamental prerequisites of any attempt to enact special timber tax-exemption laws. As has been pointed out, special forest tax laws "obviously.....would not be a remedy for unsuitable allocation of public functions, inefficient organizations, and wasteful operation of local government, or for inaccurate assessment of property and haphazard collection of the property tax" (3, p. 17). For this reason, the Forest Service has strongly recommended that, in addition to such special legislation, serious consideration be given to so improving the system of assessment of property and collection of taxes that all property be assessed at its true value and all taxes be collected or impartial penalties be applied uniformly for non-payment, and furthermore, that governmental functions be assigned to the branch or unit of government best able to exercise them most efficiently and at the lowest cost commensurate with that efficiency, with earnest attempts to simplify the governmental structure, also aimed at reduction in cost of operation. Such fundamental improvements would alone do much toward solving the whole forest-tax problem, including that of forest land tax-delinquency. It may also be desirable, however, to enact a special forest tax law adjusting the property tax to the deferred-yield situation characteristic of depleted forest properties, although at present in the Yazoo Delta this need is secondary.

8/ For further suggestions looking toward improved assessment practices, see (2), pp. 322-324, 328-329).

In connection with any discussions of special forest-tax laws for Mississippi in general or the Yazoo Delta in particular, attention must again be directed to the system of timber taxation now in effect under the provision of Sections 3145-3146 of the 1930 Code. As stated previously (page 8), forest land is classified either as "timbered" (bearing timber currently merchantable in local practice) or "uncultivatable" (clear-cut or bearing timber of smaller than merchantable size), the assessed values of the two classes of land being generally equal. Timber itself, whether held by the owner of the land on which it stands, or by another as lessee, is assessed only if currently merchantable, the volume assessable being submitted in the owner's or lessee's "true list," which is generally accepted by the assessor as correct, or, if not so submitted, being copied by the assessor from earlier assessment rolls. It is admitted that such a method frequently results in wierdly inequitable assessments. Further, the general effect of the present practice is to exempt all immature second-growth timber (not timberland) from payment of the property tax. This anomalous condition makes owners hesitate to classify forest lands under forest tax laws of the type with which Mississippi has recently experimented and subsequently discarded.[9] The exemption of immature timber,[10] although authorized in one state (California State Constitution, Art. 13, Sec. 12 3/4), has been demonstrated as unsatisfactory as a permanent solution of the forest tax problem (2, pp. 604-610).

The one experiment with the yield tax, previously described, should be ample warning to Mississippi of the difficulties inherent in this plan. Not one acre of privately owned forest land in Mississippi was ever classified under the provisions of this act. In no state where a plan of this general type has been enacted has any substantial portion of the private forest land been brought under its provisions, and in no state have any but pitifully small returns to state or local governments been derived from yield taxes (2, p. 390). The yield tax, since it is entirely divorced from the property tax in base, rate, and time of payment, puts forest owners in a position of exposure to the danger of attacks from other interests and is out of harmony with requirements for local public revenue. Unless it extends more reduction than justice permits, the tax advantage under an optional yield-tax law does not induce many owners to seek classification of their land under its terms, in view of the restrictions on forest use generally imposed as a condition of its application.

The basic problems described in the foregoing pages are those on the solution of which depends in large measure the development of a system of sound and equitable taxation of forest land in the Yazoo Delta. Beside their importance and difficulty, the problem of special forest-tax laws becomes minor, for, until these major problems are solved, no special forest law would have any permanently beneficial effect. From the standpoint of forestry in other parts of the State, however, it may be well worth while to consider enactment of one of the three types of forest-tax laws proposed as a result of the special study by the Forest Service and explained in detail in its report on the subject (2, pp. 576-608). Obviously, such a law should be adapted to Mississippi land-use conditions, as well as to the constitutional and statutory provisions governing taxation.

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[9] Sec. 5980 - 5988, 1930 Code. A law providing for an annual tax on land, exemption of tax on timber, and a yield tax on products when cut; repealed in 1932.

[10] A measure of this type (H.B. 1092), exempting from property taxation all standing timber under 12 inches in diameter 1 foot above the ground, has just been enacted by the Mississippi Legislature, too late for special study in connection with this investigation. It was approved by the Governor April 6, 1938.

SUMMARY

This paper has discussed the background of land taxation in the Yazoo Delta of Mississippi and the assessment practices followed there. It has shown that the ad valorem, levee, and drainage taxes to which forest land and timber in each of five representative counties are subject are greatly in excess of a reasonable tax which would permit investment in such lands under existing conditions; this results in widespread tax delinquency, which, it has been indicated, arises from several interrelated problems.

The first problem, and the one most difficult of solution, is that caused by the haphazard creation of a host of overlapping, frequently unstable, and often unnecessary drainage districts, each with a heavy outstanding bonded debt requiring high debt-service taxes, based on "benefit" assessments bearing no consistent relation to the actual benefit conferred by the improvements. The recent refinancing of these districts, while a step in the right direction, is not a solution of this problem. Indeed, the legal and fiscal difficulties involved in a permanently sound solution are too great to permit the development of such a program in detail without going far beyond the scope of this report. Instead, two alternative approaches to the problem have been discussed. The more promising would involve legislative action designed to bring about a readjustment of the drainage taxes in accordance with the actual benefits to the properties concerned.

The second problem is that presented by faulty assessment. It has been shown that the artificial system of land classification now embodied in the Mississippi Code, together with illegal and haphazard assessment practices, tend to the "freezing" of land and timber assessments at a uniform figure for each land-use class in a county, with no relation to the factors affecting the true value of individual properties. The solution here lies in so improving both law and practice in respect to assessment that all land and timber is assessed at its actual value (such as would be determined by an informed buyer and informed seller trading without compulsion in the open market), as nearly as this may be determined, taking into consideration for each property all the pertinent factors.

A third problem is that of the special school and road districts, set up with district autonomy in finances, frequently overlapping, and in most instances without adequate financial foundations. The solution here is obvious: Abolition of the districts as rapidly as existing bonded debts can be retired or otherwise provided for, plus establishment of the county as the basic unit of financing and administration. Also a greater degree of State supervision and support of school and road functions would probably be desirable.

Other problems exist--lack of uniformity in tax collection and enforcement procedure, the disposition of lands forfeited to the State for tax delinquency, county bond issues beyond county means of amortization--but most of these problems would be solved in large measure by the same improvements in law and practice necessary to solve the major problems outlined above.

A special forest-tax law, while perhaps desirable as an aid to forestry elsewhere in the State, is at present of relatively minor importance in the Yazoo Delta until the above problems have been met and overcome. Enactment of such a law, without first settling the other problems, would be of no permanent avail in reducing taxes on forest land in the Delta to the point where use of such lands for growing forests would be economically practicable.

The problems set forth in this paper can be solved, permanently and equitably by the people of Mississippi and the Yazoo Delta. Indeed, they alone can settle them. Unsolved, the outlook is for continued devastation of land and its forest cover, increasing tax delinquency, continued abortive attempts to grow cotton on forest land not adapted to this crop, increasing tenancy, and further decline in standards of living. Once the problems are solved, however, and a sound and equitable system of taxation established, the forest land of the Yazoo Delta can again take its proper place in the economic development of the Delta, thereby enhancing the welfare both of its own people and of those in commercially related areas.

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OCCASIONAL PAPER NO. 75

July 27, 1938

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THE RELATION OF BIRDS TO THE ESTABLISHMENT OF LONGLEAF PINE SEEDLINGS IN SOUTHERN MISSISSIPPI

By

Thomas D. Burleigh, Associate Biologist,
United States Bureau of Biological Survey.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

THE RELATION OF BIRDS TO THE ESTABLISHMENT OF LONGLEAF PINE SEEDLINGS IN SOUTHERN MISSISSIPPI

By Thomas D. Burleigh, Associate Biologist,
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Introduction

The general lack of longleaf pine (Pinus palustris Miller) reproduction on much of the cut-over pinelands in the Gulf States has long been a serious problem. Even in years when the longleaf seed crop was apparently sufficient to restock through natural means, on much of the nonproductive cut-over acreage relatively few seedlings survived. This is exceedingly important because of the relative infrequency of good longleaf seed years. Although some of the seed was viable, and germinated and produced healthy vigorous seedlings where undisturbed, most of the seed disappeared after a short time. A similar lack of success has been found with seed sown artificially. A notable example was the unsuccessful attempt in 1920 by the Great Southern Lumber Company, at Bogalusa, La., to reforest 2,000 acres with longleaf pine; apparently not a single seed survived long enough to produce a seedling. In equally discouraging trials in sowing longleaf pine seed, made at McNeill, Miss., in 1928 by the Southern Forest Experiment Station, a total of 8,100 seeds planted in 81 unprotected seed plots yielded only three seedlings. Evidently either rodents or birds were responsible for the disappearance of this seed; and to determine whether the controlling factor was one or both of these agencies, field investigations were initiated by the writer in September 1935, in cooperation with the Southern Forest Experiment Station. The Harrison Experimental Forest, near Saucier, Miss. (20 miles north of Gulfport), was selected for the study as being typical of many cut-over longleaf pine areas of the central Gulf States region.

Rodents not a Factor

As a preliminary step in this study, intensive trapping was carried on to find out what rodents were present on this area, their relative abundance, and under what conditions they existed in greatest numbers. It soon became evident that both mice and rats were abnormally scarce, for surprisingly few were caught. The possibility suggested itself that this was a year of low ebb in rodent numbers, since it is now an accepted fact that these mammals have more or less definite cycles of abundance and scarcity. Repeated trapping, however, during the succeeding 2 years, has merely emphasized this extreme scarcity. It would appear, therefore, that under existing conditions rodents are not a factor in the lack of reproduction on cut-over longleaf pine lands in southern Mississippi.

Birds and Longleaf Pine Reproduction

Attention was next directed to birds as one of the probable causes of insufficient reproduction, and results are sufficiently conclusive now to justify the assumption that birds are largely responsible for this lack of seedlings. Because certain species of birds were suspected of being guilty of the disappearance of much of the longleaf pine seed, emphasis in this study was placed on their food habits late in fall and early in winter. Sparrows, which are well-known seed-eaters, have frequently been the source of much trouble about nurseries, but an analysis of the stomach contents of 12 species of sparrows occurring on the Harrison Experimental Forest during this interval showed that they could be entirely disregarded in this study; only rarely were fragments of pine seed included in the food eaten, since its size probably renders it undesirable to such species. Robins (Turdus migratorius Linnaeus) have acquired the reputation of eating considerable pine seed during the winter, but both observation and the examination of stomach contents proved this accusation to be unfounded. Without exception, tree seeds eaten by robins came from fleshy fruits such as the dogwood and the black gum. Flocks of robins encountered in the pine woods may appear to the casual observer to be eating pine seed, but if they are watched for any length of time they are generally found to be interested mainly in gallberries (Ilex glabra A. Gray), an unfailing source of food in such a situation.

Other birds, however, were not so innocent, as the following data attest. In order of their abundance, the species showing a decided preference for longleaf pine seed late in fall and early in winter were the southern meadowlark (Sturnella magna argutula Bans), the mourning dove (Zenaidura macroura carolinensis Linnaeus), the bobwhite (Colinus virginianus Linnaeus), and four species of blackbirds--the cowbird (Molothrus ater Boddaert), the rusty blackbird (Euphagus carolinus Muller), Brewer's blackbird (Euphagus cyanocephalus Wagler), and the red-winged blackbird (Agelaius phoeniceus Linnaeus).

It was expected that the number of meadowlarks present during the winter would be materially increased by the appearance of flocks of migrants from the North, but this did not prove to be the case. No specimens taken could be referred to the northern race, all flocks observed being unquestionably composed of individuals resident in southern Mississippi. Although the first longleaf pine seed began to fall during the latter part of October, it was not until the first touch of cold weather several weeks later that more than a trace of pine seed was found in the contents of meadowlark stomachs examined. Insects (notably grasshoppers) formed the major portion of the food eaten until low temperatures resulted in their sudden scarcity, after which pine seed was consumed in increasing quantities. This relationship between inclement weather and food preference was so consistent throughout the winter of 1935-36 that it is entirely probable that in mild winters meadowlarks do far less damage than they did during this first year of the study. After the middle of November, few stomachs were examined that did not hold at least a few fragments of pine seed, but not until after a sudden drop in temperature, followed by rain and high winds, did pine seed form 75 percent or more of the total food consumed.

Mourning doves proved to be consistent eaters of longleaf pine seed, and although less numerous than the meadowlarks, they were probably more destructive. A male bird--a typical example--taken on November 12, 1935, had nine whole seeds in its crop and two partially digested ones in its stomach. Bobwhites also destroyed many seeds, for the few stomachs of this species

EFFECT OF BIRDS ON LONGLEAF PINE REGENERATION

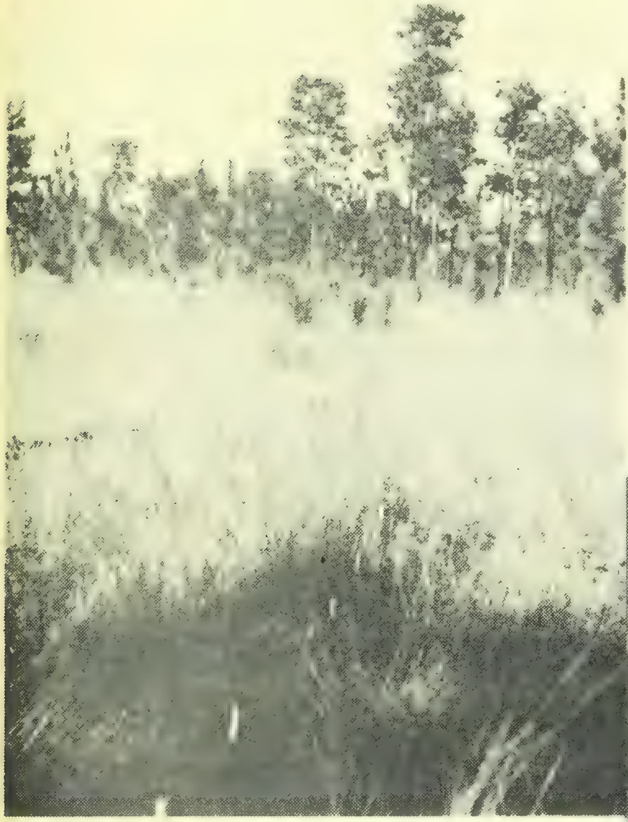

FIGURE 1.--1935 longleaf pine seeding plots, showing almost complete failure in reproduction due to bird damage in good seed year.

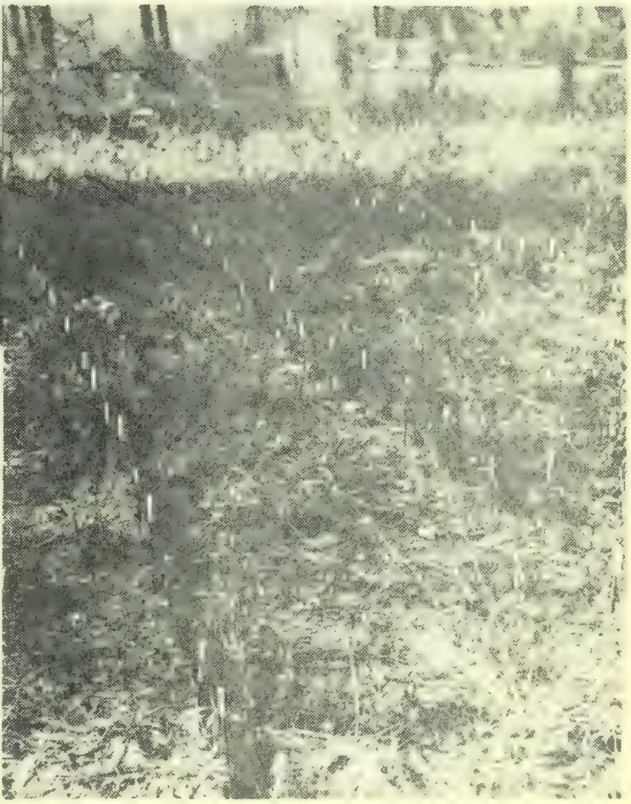

FIGURE 2.--1936 longleaf pine seeding experiment, in off seed year. Note good reproduction and no bird damage.

analyzed in December 1935 were found crammed with pine seeds to the practical exclusion of all other food.

In 1935, not until early in December did the first flocks of blackbirds appear in southern Mississippi, but their numbers and their voracious appetites make them an important factor in limiting longleaf pine reproduction. It was not uncommon to find 200 or more individuals (of two or three species) in the restless flocks that were encountered daily. In feeding they showed a marked preference for burned areas; although seen about land under cultivation, they were never observed in the unburned "roughs." Obviously they would have experienced little difficulty in procuring food even where the grass was thickest, but rarely, if ever, did they feed under such conditions. Examination of the contents of the stomachs showed that pine seed was always eaten when it was available, but since other seeds and insects were never left untouched, the pine seed rarely exceeded 50 percent of the total food eaten. This was sufficient, however, for the birds to prevent the development of most seedlings on any area in which they were feeding, for they invariably remained in compact flocks that overlooked little material acceptable as food. After the seed had germinated, it was still in danger of being severely injured, if not destroyed, for the endosperm and seed coat clinging to the cotyledons were as acceptable as the seed itself. In this connection it was interesting to compare the damage done by the blackbirds with that done by the meadowlarks late in winter. When taking the endosperm with their short, conical bills, the blackbirds merely clipped off the tips of the cotyledons; whereas the meadowlarks, having relatively long, stout bills, tended to cut off the entire seedling near the root collar.

In 1935 there was a very heavy longleaf pine seed crop, in marked contrast with the fall of 1936, when practically no longleaf pine seed was produced in southern Mississippi. This affected almost immediately the normal winter bird population of this area. Meadowlarks, normally resident throughout their range on the Gulf Coast, gradually decreased, until early in December there remained only 10 percent of the number present the preceding winter. Blackbirds appeared in small flocks that lingered but a day or two before disappearing. Doves were far from plentiful, the scattered flocks seen being invariably about cultivated fields. The same was true of many coveys of quail that formerly could be found in the open pine woods.

This dependence on longleaf pine seed as a source of food late in fall and early in winter was later emphasized by the results obtained on experimental areas established to check seed survival. These experiments had a two-fold purpose: To test the advisability of direct seeding under existing conditions, and to determine if possible what method of direct seeding would be most successful. Accepted field technique was used in varying the actual seeding. Part of the seed was merely broadcast and not covered; another part was broadcast and covered with a light mulch of pine "straw"; and still another part was planted in drills to a depth of approximately a quarter inch. Each of these methods was further tested by varying the ground cover. A third of each plot remained in the natural "rough," another third was burned just prior to sowing, and the remainder was cultivated.

After one year, the plots established early in December 1935 showed clearly the scarcity of rodents as well as the actual effect of birds on longleaf pine regeneration. Where the seed was covered with a light mulch or planted in drills, germination was unhampered, indicating that rodents were not present in any numbers. Almost at once, however, damage by birds was clearly evident in the injury or total disappearance of the seedlings; the presence of the endosperm and seed cap resulted in the survival of only an occasional seedling that apparently had been overlooked. Seed left uncovered disappeared within 1 or 2 days. A careful check of these plots a year later showed a survival of less than 1 percent, leaving little doubt of the inadvisability of attempting direct seeding under the existing conditions.

The second year of the study (fall of 1936), when the cone crop was practically nonexistent and birds were scarce, radically different results were obtained on two series of plots established similarly to those in 1935. On one series (A, table 1), on a cut-over area adjacent to trees that had borne a good crop of cones the previous year, the seed was practically untouched; seed germination and survival of the seedlings were satisfactory beyond the most sanguine expectations. Another series (B, table 1) was intentionally placed under the most adverse conditions that could be found on the experimental forest--within a short distance of a site used the previous year, where damage by birds had been rather severe. Nevertheless, the survival here, despite the activities of four meadowlarks that appeared before all the seed had germinated, was sufficiently large to justify direct seeding under existing conditions.

Table 1.- Survival of longleaf pine seed sown late in December 1936

Plot treatment	Series	Percentage survival of 350 seeds sown		
		In drills	Broadcast and exposed	Covered with a light mulch
Natural rough	A [1]	97	91	[3] 16
	B [2]	15	33	34
Cultivated	A	96	77	76
	B	17	41	16
Burned	A	83	60	51
	B	35	17	13

1/ In Series A loss in many cases was due to damaged and infertile seed, or to factors other than birds and rodents.

2/ In Series B loss of seed and destruction of seedlings were caused chiefly by the activities of meadowlarks.

3/ Low survival was due to activities of several harvest mice (Reithrodontomys).

Summary and Conclusions

The following conclusions seem warranted by results of field investigations carried on during approximately 2 years on the Harrison Experimental Forest in southern Mississippi.

1. Under present conditions, in the locality studied, rodents are not an important factor in the success or failure of longleaf pine reproduction.

2. Certain birds, including the southern meadowlark, the mourning dove, four species of blackbirds (the cowbird, the rusty blackbird, Brewer's blackbird, and the red-winged blackbird), and the bobwhite, are responsible for the disappearance of a large part of the annual seed crop of the longleaf pine.

3. These birds depend to such an extent on this source of food late in fall and early in winter that their movements are largely governed at these seasons by the quantity of longleaf pine seed produced.

4. Because of this dependence on longleaf pine seed, obtaining natural reproduction will always be difficult, and unless aided by planting, will require many years.

5. Direct seeding should not be undertaken during years when seed is produced in abundance. Maximum natural survival can apparently be obtained when the cone crop is light and birds are relatively scarce. Best results from direct seeding can also be expected during such years.

It should be emphasized, however, that these conclusions apply only to cut-over longleaf pine lands in southern Mississippi. Before it is possible to recommend any general practices throughout the range of the longleaf pine, studies similar to this should be carried on in other southern States, such as Texas, Alabama, Georgia, and Florida, where undoubtedly local conditions will be found to have a direct bearing on the problem of natural regeneration of longleaf pine.

OCCASIONAL PAPER NO. 76 AUGUST 15, 1938

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE POLE-FRAME BRUSH DAM– A LOW-COST MECHANICAL AID IN REFORESTING GULLIED LAND

by

H. G. Meginnis, Silviculturist

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

THE POLE-FRAME BRUSH DAM- A LOW-COST MECHANICAL AID IN REFORESTING GULLIED LAND

by

H. G. Meginnis, Silviculturist,
Southern Forest Experiment Station

Extensive erosion-control projects undertaken in the Southern States during the past 5 years demonstrate that even large, actively eroding gullies in this region can be stabilized and controlled eventually by planting them to trees and other hardy soil-binding plants. Commonly in these operations, small temporary check dams are constructed in the gullies to collect and build up deposits of productive soil outwash on which the vegetation can gain a suitable foothold. These simple structures usually are built of rather temporary materials and, unlike the stronger and more permanently constructed types of check dams, are designed primarily to improve the growing site for vegetation rather than to afford long-term mechanical protection to the gully channel. In the South, these temporary dams generally are used in gullies with relatively small drainage areas rarely exceeding a few acres in extent, although the gullies themselves may be very large and actively eroding and may carry a comparatively great flow during storms. When temporary check dams are used, the vegetation obviously must be depended on to stabilize the bottom of the gully channel within the life of the materials—usually 3 to 5 years.

Many types of check dams have been used. Ordinarily they are constructed of straw, brush, logs, loose rock, woven wire, or other inexpensive materials readily obtainable. In the Gulf States the scarcity of straw and rock largely precludes the use of these materials, and although woven-wire dams of several types have been employed widely, the nominal cash outlay required to build them has tended to limit their use by farmers and landowners. Log dams, when properly constructed, are sturdy and dependable, but they are likely to be wasteful of materials and are time-consuming to build. On the other hand, brush dams are favored generally because they can be constructed easily and quickly from inexpensive materials available on most gullied areas.

Perhaps the most simple type of brush dam is that formed by laying brush boughs crosswise of the channel and weighting the brush mass down with logs. These simple brush barriers, which were used as early as 1915 by Maddox[1] in reforesting gullied lands in western Tennessee, have proved very effective in mature gullies that have formed on moderate slopes and that do not drain large areas or carry excessive quantities of run-off.

On most present-day projects, more sturdily constructed dams, designed to withstand relatively great flow, are favored. The two most widely employed types are: (1) the longitudinal or parallel dam with the brush laid lengthwise of the channel and anchored with posts and wire or with staked poles; and (2) the double row-post dam with the brush laid crosswise of the gully between a

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[1] Maddox, R. S. Reclamation of waste lands. Tenn. Div. Forestry Circ. No. 10, 10 pp., illus. October 1926.

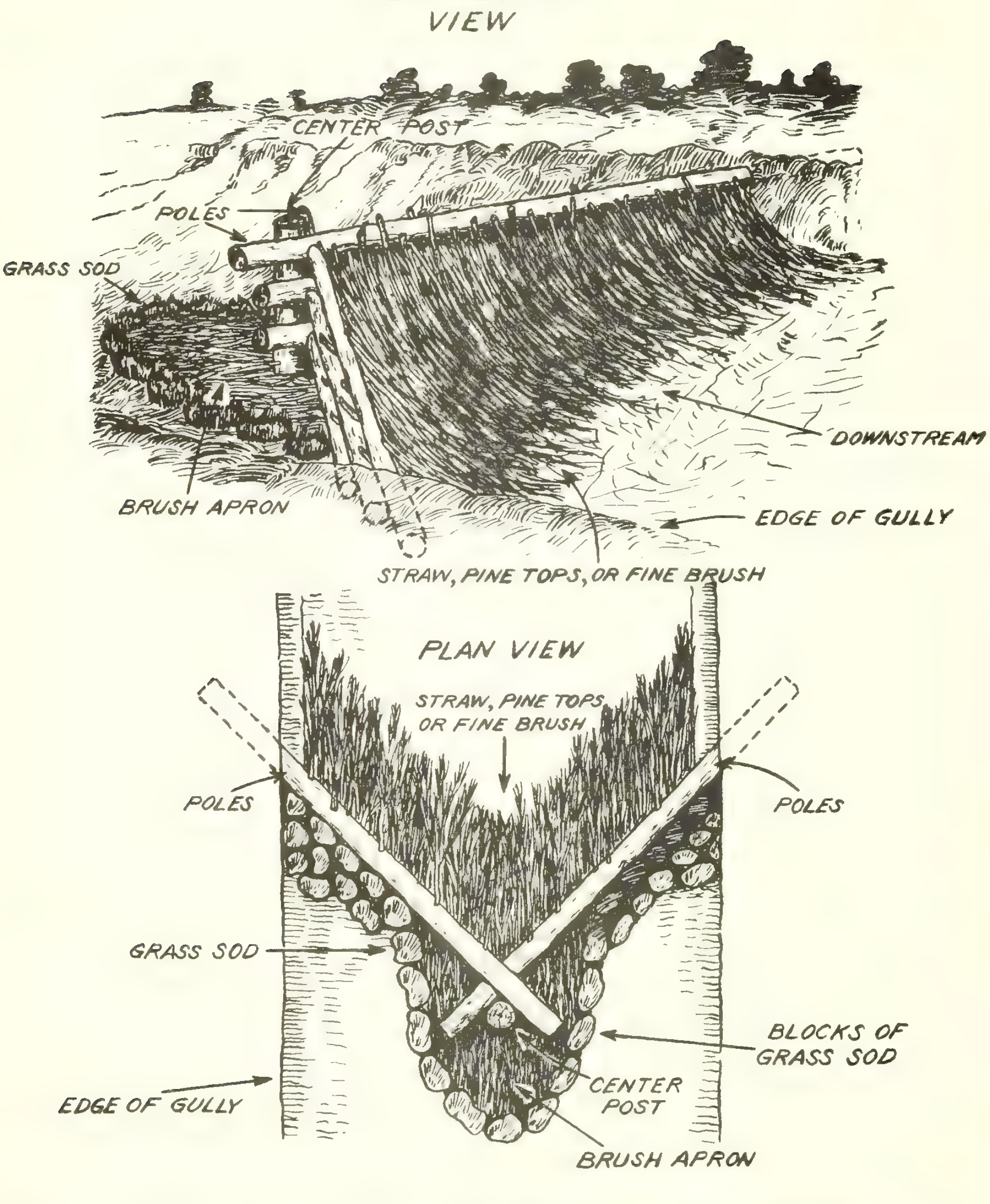

Fig. 1 - A simple brush and pole dam that is easily constructed and requires a minimum amount of brush and other materials. One post is set in the center of the drainage and a frame work of notched poles laid against this. Straw, pine tops, or fine brush is packed against the upper face. A brush and sod apron protects the base of the dam at the point where the flow is concentrated. The ends of the dam are embedded securely in the gully banks and the lower pole is embedded in the gully bottom.

double row of posts and held in place by wire ties.[2] The parallel dam is used commonly in narrow, head-feeder gullies, whereas the crosswise dam is favored in the larger, wider washes. The latter, when properly constructed, is perhaps the sturdiest of all the well-known types of brush dam.

A type of brush dam that has proved highly dependable, and which has certain features that recommend its use on projects involving the reforestation of low-value gullied lands, was developed by the writer in 1932 in connection with early studies carried on by the Southern Forest Experiment Station near Holly Springs, Marshall County, Miss. This type of structure, called the pole-frame brush dam, was rather extensively employed in that locality but has not been described heretofore and so far as is known has not been used elsewhere. The dam consists of a substantial anchor post set in midchannel to a depth of 24 to 36 inches, against which is laid a framework of poles backfilled on the upstream face with layers of brush boughs that filter out and retain the soil outwash. The downstream ends of the poles are overlapped at the anchor post, one on top of the other, much like the rails of an old-fashioned worm fence, while the other ends are notched well into the gully banks or are held in place with driven stakes or small posts. A typical pole-frame dam is illustrated in figure 1, and other essential details of construction are depicted in figures 2, 3, and 4.

Experience with this type of brush dam demonstrates that the poles of the framework should be sloped slightly toward the anchor post to provide a low center at the point of overfall. This tends to concentrate the flow and prevents the water from cutting around the ends of the dam. The poles do not need to be notched into each other at their junctures, with the exception of the two lowermost pairs of the framework, which should be fitted rather closely together in one plane to prevent undercutting and to hold the brush apron firmly in place. The pole framework may be bound to the anchor post with wire ties when very light poles are employed or where the character of flow requires an unusually strong dam. Experience at Holly Springs, however, indicates that wire anchorage is not highly essential and usually can be dispensed with, since the force of the run-off is directed so as to wedge the pole framework tightly against the anchor post and is seldom capable of floating poles of average dimensions. Furthermore, the soil deposits accumulating behind the dam also provide much additional weight and anchorage. Rough, tapering poles of any convenient size, including rather large logs, may be used, but those about 3 to 8 inches in diameter are easiest to cut and handle. They may be of pine or other softwood, although timbers of oak or other hardwoods are heavier and more durable.

This type of dam should not exceed about 18 inches in height at the center post or point of overfall. Higher dams may provide somewhat greater deposits of plantable soil, but they are much more likely to fail than are low dams and are almost always difficult to maintain. It should also be emphasized

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[2] See: (1) Ramser, C. E. Brief instructions on methods of gully control. U. S. Dept. Agr., Bur. Agr. Engin., 35 pp., mimeographed. August 1933. (2) U. S. Dept. Agr., Forest Service. Handbook of erosion control engineering on the national forests. 90 pp. 1936. (3) Ayres, Quincy Claude. Soil erosion and its control. 365 pp. McGraw-Hill Book Co. New York and London. 1936.

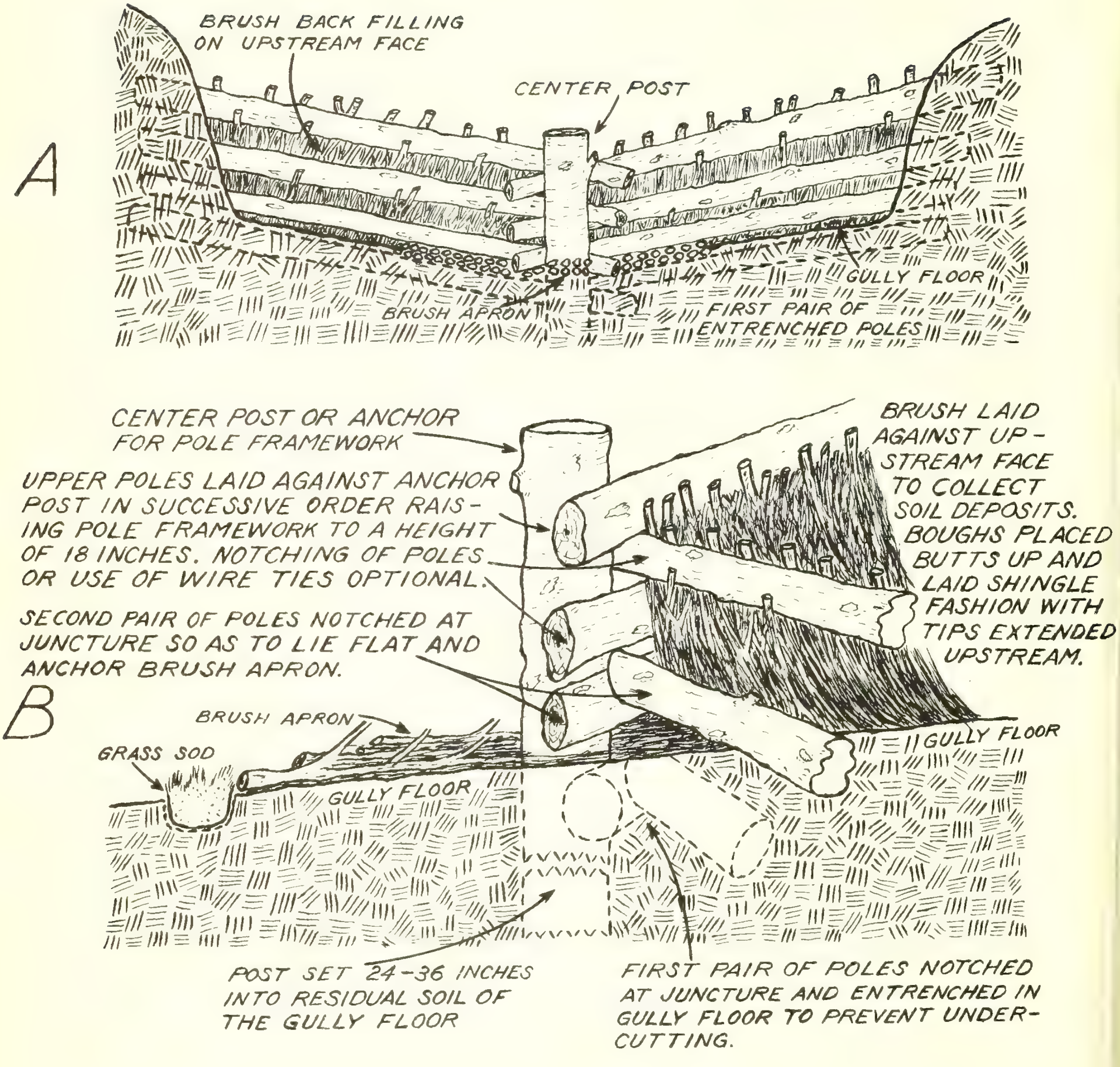
A
BRUSH BACK FILLING ON UPSTREAM FACE
CENTER POST
GULLY FLOOR
BRUSH APRON
FIRST PAIR OF ENTRENCHED POLES
CENTER POST OR ANCHOR FOR POLE FRAMEWORK
UPPER POLES LAID AGAINST ANCHOR POST IN SUCCESSIVE ORDER RAISING POLE FRAMEWORK TO A HEIGHT OF 18 INCHES. NOTCHING OF POLES OR USE OF WIRE TIES OPTIONAL.
SECOND PAIR OF POLES NOTCHED AT JUNCTURE SO AS TO LIE FLAT AND ANCHOR BRUSH APRON.
BRUSH LAID AGAINST UPSTREAM FACE TO COLLECT SOIL DEPOSITS. BOUGHS PLACED BUTTS UP AND LAID SHINGLE FASHION WITH TIPS EXTENDED UPSTREAM.
B
BRUSH APRON
GRASS SOD
GULLY FLOOR
GULLY FLOOR
POST SET 24-36 INCHES INTO RESIDUAL SOIL OF THE GULLY FLOOR
FIRST PAIR OF POLES NOTCHED AT JUNCTURE AND ENTRENCHED IN GULLY FLOOR TO PREVENT UNDERCUTTING.

Fig. 2 — Pole frame brush dam. (A) Downstream elevation showing poles sloped toward center of structure and with ends notched well into the banks of the gully. (B) Lateral section through mid channel, illustrating manner of laying pole framework against anchor post as well as other construction details.

that since the pole-frame dam is not designed to operate as an overfall structure, the upstream face should not be backfilled with soil with a view to making the dam watertight. This is commonly done, but insofar as temporary brush dams are concerned, the practice has little to recommend it. It is not necessary to impound fully the run-off in order to collect ample deposits of soil, and a backfilling composed of permeable layers of brush will filter out the soil and gradually will build up a capacity deposit without subjecting the structure to the hazards that attend a watertight structure. The tendency to overlook this point frequently has resulted in the unnecessary failure of brush dams with consequent overemphasis on costly heavy-duty dams in situations where much simpler structures would suffice.

Of the materials commonly available for backfilling, pine tops or cedar boughs are usually best, although well-trimmed hardwood boughs, preferably cut with the leaves adhering, may be used effectively. The boughs should be overlapped in shingle-fashion on the gully floor with the tips extending upstream and the butts threaded through the openings and hooked into the pole framework. Straw, hay from wild grass, corn stover, sorghum bagasse, or other types of farm wastes make excellent backfilling for dams; they may be used either alone or (preferably) in admixture with the brush.

Normally, the materials used in brush dams are cut from damaged, unthrifty or poorly formed trees, from unmerchantable tops, or from loppings. Usually all parts of a tree can be utilized efficiently in constructing this type of dam. With trees of pole size, the butt cuts are used as anchor posts or split into stakes, the trunk and larger limbs are used in the pole framework, and the smaller boughs as backfilling. The large, open-grown or otherwise poorly formed trees also can be used in their entirety, provided they are southern pines or easily split hardwoods. Trees of sapling size, 3 inches or larger in diameter, are also usable, and where they are plentiful, dams can be constructed more easily from them than from larger trees.

The use of an apron is optional, and this feature was omitted from the majority of pole-frame dams constructed at Holly Springs without appreciably affecting the quality of the performance. Little additional material is required, however, to construct a substantial apron, which provides an additional safeguard by preventing the dam from being undermined. The use of grass sod as a border for the apron (figs. 1, 2, and 3) is not highly essential but may be desirable where only brush backfilling is used or in situations where drainage waters from above are not likely to bring in waste seed from native or domestic plants. Of the species grown in the Gulf States, Bermuda grass (Cynodon dactylon Pers.) is the most aggressive and best suited for protecting the base of check dams. The sods need not be spaced as closely as illustrated in figure 1; sods 1 foot apart are amply close.

At Holly Springs, pole-frame dams have been used successfully in all types of gullies common to the loessal uplands and adjoining Coastal Plain, and under the conditions found here they have proved quite dependable. Although they utilize the same kind of materials and in smaller amounts than is required in the Maddox type of dam, pole-frame dams are stronger and more dependable in channels carrying relatively heavy stormflow. Furthermore, this kind of dam with only minor changes can be adapted readily to suit local needs. In small, relatively quiescent washes, a very simple framework of short poles, backed by a small quantity of brush boughs, will suffice. By using heavier,

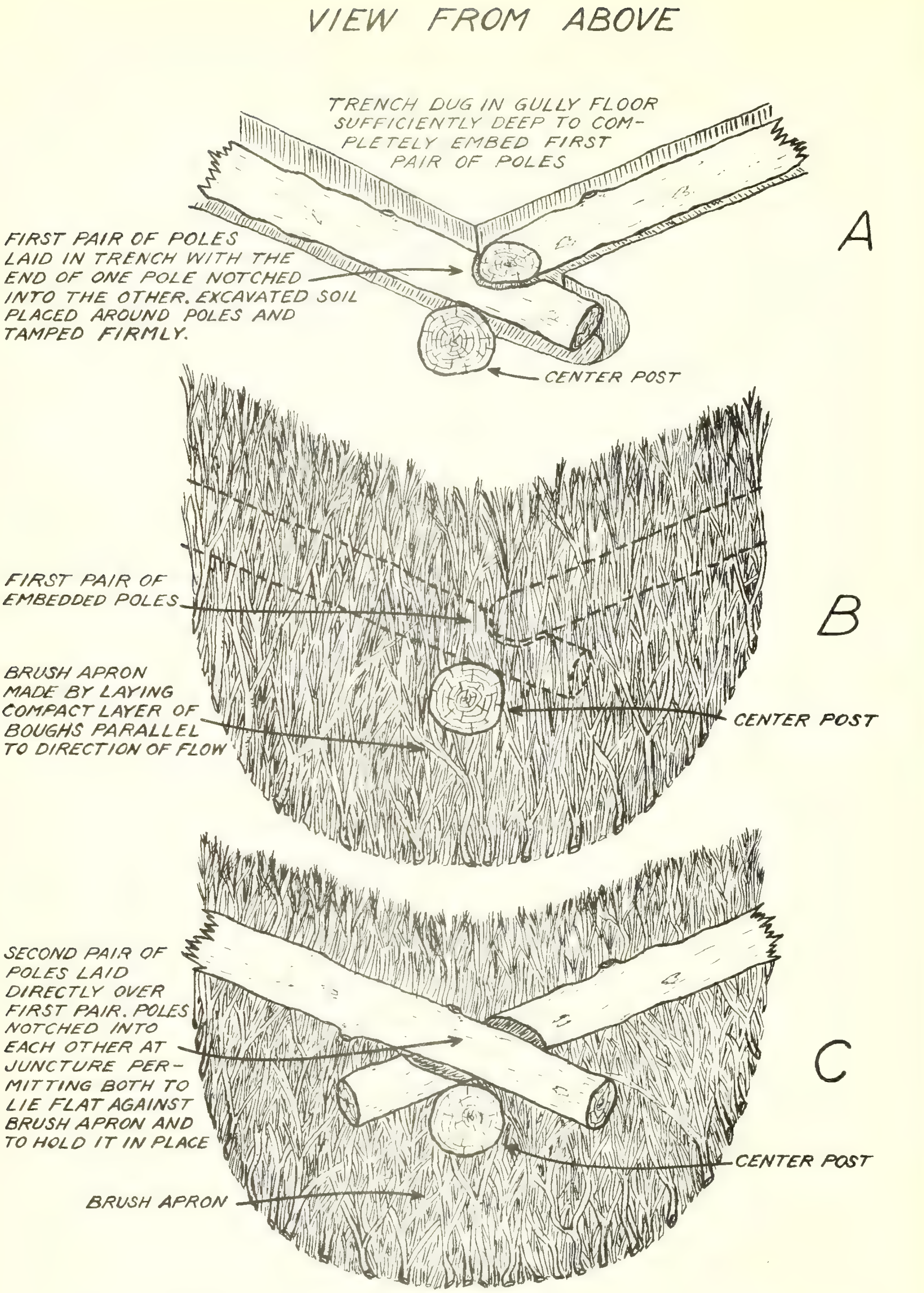
VIEW FROM ABOVE
TRENCH DUG IN GULLY FLOOR SUFFICIENTLY DEEP TO COMPLETELY EMBED FIRST PAIR OF POLES
A
FIRST PAIR OF POLES LAID IN TRENCH WITH THE END OF ONE POLE NOTCHED INTO THE OTHER. EXCAVATED SOIL PLACED AROUND POLES AND TAMPED FIRMLY.
CENTER POST
FIRST PAIR OF EMBEDDED POLES
B
BRUSH APRON MADE BY LAYING COMPACT LAYER OF BOUGHS PARALLEL TO DIRECTION OF FLOW
CENTER POST
SECOND PAIR OF POLES LAID DIRECTLY OVER FIRST PAIR. POLES NOTCHED INTO EACH OTHER AT JUNCTURE PERMITTING BOTH TO LIE FLAT AGAINST BRUSH APRON AND TO HOLD IT IN PLACE
C
CENTER POST
BRUSH APRON

Fig. 3 – Steps entailed in constructing the foundation for a pole-frame dam: (A) First pair of poles entrenched in the gully floor; (B) Placing boughs for a brush apron; (C) Second pair of poles notched at juncture and laid over brush apron.

more durable material or by making minor modifications in construction (fig. 4), this type of dam can be used effectively also in the very large laterally extended gullies that are characteristic of this region. So far as is known, these dams have not been used in finger gullies draining steep mountainous slopes comparable to those of the Southern Appalachian Region, and their performance under such conditions is problematical; they have been successfully used, however, in the more steeply inclined scouring channels representative of the gullies in the Upper Coastal Plain. In very narrow v-profile gullies, the pole-frame dam probably can be constructed with less expenditure of labor than any other common type of brush dam of equal dependability.

Perhaps the outstanding feature of pole-frame dams is their nominal cost. Virtually the entire cost in building any brush dam is for the labor expended in cutting, trimming, and placing the brush and in providing suitable anchorage. Experience at Holly Springs indicates that the pole-frame dam requires less brush than the two more popular types of brush dams mentioned above and that a further saving is effected by the efficient mode of anchorage employed, which necessitates the setting of relatively few posts or stakes. Cost records obtained in 1934 and 1935 show that 426 pole-frame dams constructed in typical gullies required an average of only 1.13 man-hours of labor per dam. These structures were built in channels 3 to 20 feet wide (average about 7 feet). Using similar, although better-supervised, labor, some 77 brush dams of the longitudinal and double-post-row, crosswise types were constructed in comparable gullies with a total labor output of 533 man-hours or 6.92 man-hours per unit. In short, one man was able to construct a pole-frame dam in about one hour, whereas almost a day of labor was required to build a dam of the other two types. The labor output for building the latter two types of dam on this particular job was probably not excessive, inasmuch as Ayres[3] cites data indicating that the average labor requirements for building these structures range from 1 to 1.5 man-hours per linear foot of dam.

Although other kinds of temporary brush dams possess their good points and have special applications, experience with the pole-frame dam prompts the belief that this type comes most closely to fulfilling an all-around need for a cheap, dependable structure that can be used in reforesting gullied land in the Gulf States. Owing to its low cost and adaptability to a wide range of gully types, the pole-frame dam should find ready application in the South and in other comparable regions where the low value of gullied lands and other circumstances may justify a minimum of expenditures for control measures.

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[3] Ayres, Quincy Claude. Soil erosion and its control. (p. 221) McGraw-Hill Book Co. New York and London. 1936.

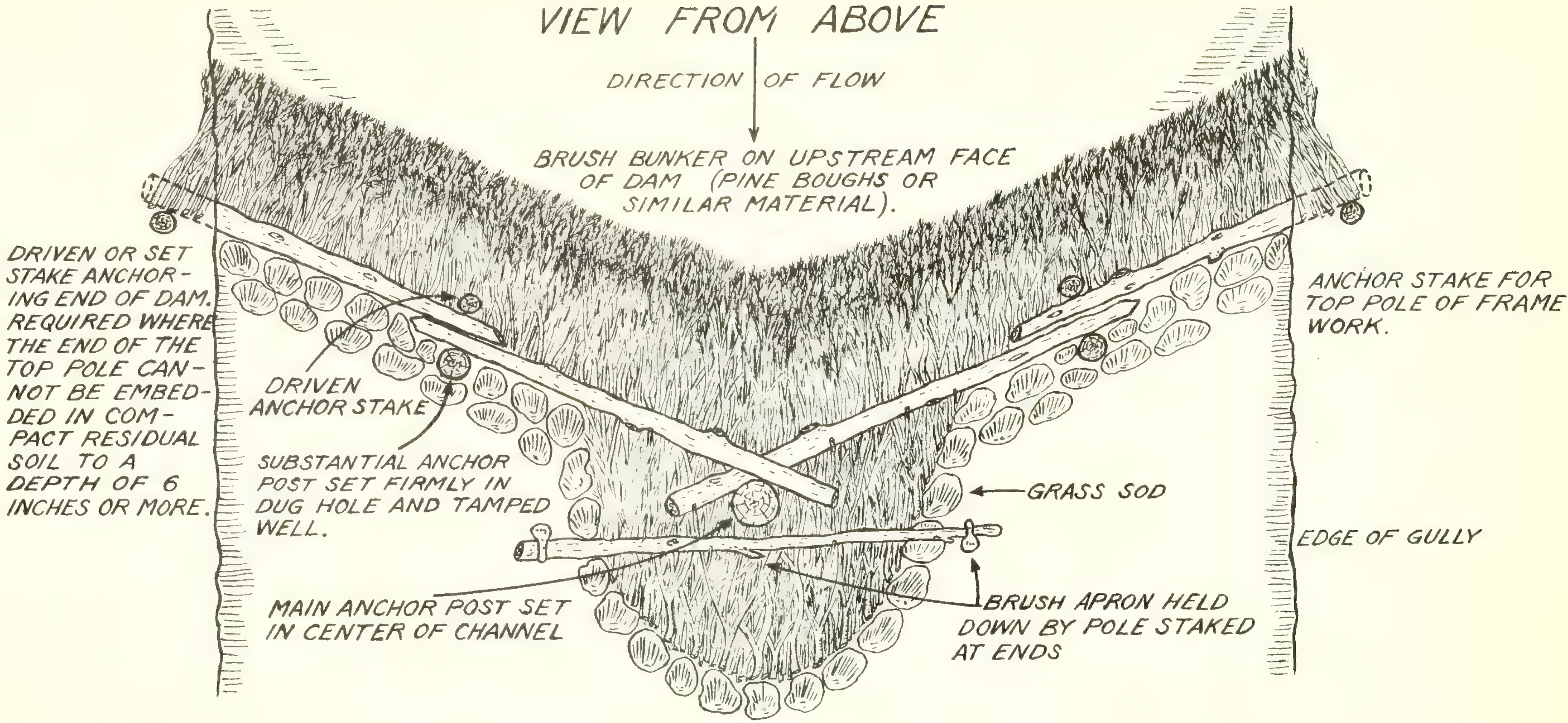
VIEW FROM ABOVE
DIRECTION OF FLOW
BRUSH BUNKER ON UPSTREAM FACE OF DAM (PINE BOUGHS OR SIMILAR MATERIAL).
DRIVEN OR SET STAKE ANCHORING END OF DAM. REQUIRED WHERE THE END OF THE TOP POLE CANNOT BE EMBEDDED IN COMPACT RESIDUAL SOIL TO A DEPTH OF 6 INCHES OR MORE.
DRIVEN ANCHOR STAKE
SUBSTANTIAL ANCHOR POST SET FIRMLY IN DUG HOLE AND TAMPED WELL.
MAIN ANCHOR POST SET IN CENTER OF CHANNEL
ANCHOR STAKE FOR TOP POLE OF FRAMEWORK.
GRASS SOD
EDGE OF GULLY
BRUSH APRON HELD DOWN BY POLE STAKED AT ENDS

Fig. 4 – Method of constructing pole-frame dam in wide washes or in situations requiring the use of poles too short to extend from center to edge of the channel. The ends of the poles are overlapped about 2 feet and are held in place by a substantial post set firmly on the downstream face of the structure and by a hardwood stake driven opposite on the upstream face. Post and stake extend above ground sufficiently to anchor topmost poles of the framework. The brush apron and anchor pole are optional but may be needed to protect the base of large dams constructed in drainages carrying heavy flows. The dam can be made stronger by setting additional stakes or posts against the pole framework, by using wire ties and heavy poles, and providing a larger quantity of brush back filling.

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

RESEARCH RESULTS IN SOUTHERN FORESTRY

by

E. L. Demmon, Director
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

RESEARCH RESULTS IN SOUTHERN FORESTRY [1]

by

E. L. Demmon, Director,
Southern Forest Experiment Station

Since 1921, the United States Forest Service has maintained, with headquarters at New Orleans, La., the Southern Forest Experiment Station, one of twelve regional forest research stations in the United States. This Station serves the eight Southern States from Florida and Georgia to Oklahoma and Texas. Its technicians study the problems involved in the protection and management of forests, reforestation, naval stores production, forest economics, relation of forests to erosion and streamflow control, and related subjects. The purposes of these investigations are (1) to determine the basic facts underlying forest production and forest protection in the region; (2) to determine the most effective use of forests in regulating streamflow and controlling erosion; and (3) to bring about the fullest and most profitable use of the 122 million acres of commercial forest land in the deep South.

Also attached to the Station are specialists in allied fields, whose work ties in closely with the Station's program; these include forest pathologists, entomologists, and biologists, assigned by their respective Bureaus of the U. S. Department of Agriculture.

The Station conducts field investigations at a number of experimental forests or outdoor laboratories in various parts of its territory. Since each of these centers of work is typical of forest conditions in its section, the results of these field studies are applicable to a wide area or broad forest type.

Silviculture

Silvicultural studies—those dealing with the science of growing trees—constitute a large part of the Station's activities. They deal largely with the determination of the best way (1) to grow desirable species in the shortest time, (2) to improve the growing forest through thinning young stands and eliminating worthless, undesirable, diseased, and infested trees, and (3) to cut merchantable timber so as to obtain the largest and most valuable yields over an indefinite period of time, i.e., on a sustained-yield basis.

Expanding markets for pulpwood and a steady demand for high-quality sawlogs, poles, piling, and other products, including naval stores, emphasize the widespread need for information on the best and most profitable methods of handling second-growth stands. The stand-improvement problem is important to most of the southern forests, which contain too many trees of little or no value and not enough trees of high value. Recent Station studies show that stand-improvement work to correct or improve this condition frequently can be done at an immediate profit. Many of the poor trees that need to be removed are hardwoods of no commercial value that can be killed readily by girdling.

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[1] Address before the Texas Academy of Science, Waco, Texas, November 11, 1938.

That this is a profitable operation is indicated by a stand-improvement experiment in a typical second-growth stand in the shortleaf-loblolly-hardwood type. When this experiment was initiated 5 years ago, 1,200 board feet of pine and hardwood sawlogs, and 3.5 cords of pine pulpwood were removed from the average acre at an immediate profit for this improvement operation alone. In addition, an average of 19 large unmerchantable hardwoods per acre were girdled to benefit the smaller pines beneath them. Cutting and girdling the large unmerchantable hardwoods, as distinguished from the other phases of stand improvement, resulted in an increased growth, in the first 5 years, of about one-half cord of pine pulpwood for each man-hour spent in girdling. At current prices and costs, the hardwood girdling has therefore approximately paid for itself in only 5 years. The pines near the girdled hardwoods will continue to gain rapidly in volume, whereas the pines near the ungirdled hardwoods on the control plot are gaining very slowly, and through mortality, may even decrease in total volume.

Regeneration

The Southern Station territory contains more than 5,000,000 acres of cut-over pine lands, mostly in the longleaf type, on which there is little or no possibility of reestablishing forests by natural means. Research is needed, therefore, to supply the owners and managers of these lands with technical information to enable them successfully to reforest these areas by planting. Research in forest regeneration, which includes studies of seed, nursery practice, and planting, has recently yielded important results in all these fields, three of which will be mentioned here.

1. A simple index to the maturity of cones of the southern pines is important, since the collection of cones too green to open is very wasteful. Such an index has recently been developed by the Station. The specific gravity of a cone was found to be the best index of its maturity, and an easy, practical way to determine whether or not a cone is mature was found to consist in dropping it in ordinary automobile crankcase oil of grade 20, S.A.E. Cones that will float in this oil are mature enough to pick.

2. Another source of considerable waste in seed and nursery practice has been the loss in viability of seeds in storage. Comprehensive studies of the overwinter storage of longleaf pine seed have showed conclusively that low moisture content of the seed and low temperature are necessary for successful storage. Germination percentages of the different seed lots that were tested after storage for 3½ months ranged from 0 to 69 percent. With such large variations, this study alone indicated possible annual savings of about $80,000 in two Southern Forest Service nurseries.

3. In establishing forest plantations, instances of both success and failure are common. A factor that contributes largely to the success or failure of a plantation is the geographic source of the seed. Studies in this field are well under way, and some have already produced very significant results. In a loblolly pine plantation established in 1927 from stock representing four different geographic sources of seed, the best height growth and the least infection with rust canker (Cronartium cerebrum or C. fusiforme) occurred in the trees grown from local seed. The difference in these respects were so striking

after only 10 years in the field that the importance of geographic source of seed cannot be exaggerated.

Naval Stores

Pitch and tar obtained from southern pines were used in Colonial times for waterproofing and caulking wooden sailing vessels—hence the name "naval stores" now applied to turpentine and rosin. For more than a century, the United States has led the world in the production of these commodities. The Station is working out improved methods of obtaining resin or "pine gum" from longleaf and slash pines and of managing timber stands for the production of turpentine and rosin. The purpose is to obtain maximum yields of gum over a long period, at the same time preserving the turpentined trees so that they may be used eventually for lumber or other products. Since the recent lowered demand for naval stores has aggravated the oversupply and prices have reached extremely low levels, lower production costs are very important. The Station consequently is investigating the effect of factors that influence production costs and is aiming to improve methods of extracting gum from the tree.

Early research in naval stores production by the Southern Station disclosed a close relationship between gum yield and the size and growth rate of trees. Gum yields increase with increased size of tree and with increased growth rate. Conservative methods of chipping yield the best results over a long period. Many of the specific practices recommended as a result of the Station's investigations have already been adopted by the industry.

Recent experiments have shown a strong relationship between the grade of rosin obtained and the yield; also between the percentage of scrape (hardened gum adhering to the face of the turpentined tree) and the yield. For timber that yields 20 barrels of turpentine per crop (10,000 faces), scrape makes up 27 percent of the raw material, whereas with "60-barrel" timber, scrape makes up only 14 percent. Furthermore, the gum from the "60-barrel" timber produces a much higher grade of rosin than that from the "20-barrel".

The value of raising cups annually has also been investigated. It was found that on low-yielding timber, cups were raised at an actual loss but that with increased yields the net return from annual raising of cups mounted rapidly.

Mensuration

One objective of research in mensuration is to make available more satisfactory information (a) on the growth and yield of forest trees and stands on various sites and at different ages, and (b) on methods of estimating the volume of standing and felled timber. Another objective deals with the improvement of technique of design and analyses adaptable to the many problems in the field of forest research.

New techniques have been developed for constructing average stand tables and curves of site quality, or site index, based on the inherent variation of average stand heights at different ages. These techniques were developed and used in a study of the growth and yield of second-growth red gum, but the methods are applicable to all species.

Many types of forest research have benefitted from the application of modern analytical technique, involving the randomization of field trials and the method of analysis of variance. As an example of the use of modern analytical technique, the problem of obtaining a reliable forest-nursery inventory by sampling the various beds has recently been worked out. This has resulted in obtaining a reliable inventory that was not expensive but that was sufficiently accurate to aid forest planting organizations in planning their operations. An overestimate of the planting stock results in great waste in moving men to handle the stock, whereas an underestimate may result in excessive mortality of the planted stock because the operations are slowed up and extend too late in the season.

Fundamental Studies

Fundamental studies are concerned with basic physiological and ecological conditions in relation to forest regeneration, growth, and succession. In the South, the study of these relationships as applied to longleaf pine has been of primary importance, since longleaf pine is a highly valuable species but unusually difficult to reproduce satisfactorily. One of the results of recent research in this field has been a determination of the effects of competing vegetation and of density of stocking on the growth of longleaf pine seedlings, which usually remain "in the grass" in a stunted condition for years after the germination of the seed. Five years after the establishment of a study with 12-year-old seedlings averaging only 0.1 foot high, where the density was 1,000 seedlings per acre, seedlings on areas denuded of associated vegetation averaged 9.2 feet high as compared with only 3.3 feet under undisturbed natural conditions. Further research in the laboratory has shown that longleaf pine seedlings grown without grass competition grew twice as fast as similar seedlings grown with grass, all other conditions being the same. These results suggest the possibility of stimulating growth of young longleaf pines by removal of the surrounding vegetation.

A recent study of the soil-moisture requirements of longleaf and slash pine seedlings showed that both species transpire and absorb water at approximately the same rate, and appear capable of surviving both extremely dry and extremely wet conditions. The soil-moisture content for optimum growth of each species is about 25 to 30 percent. The slash pine seedlings, however, require more water than longleaf pine seedlings of the same age to build the same amount of dry matter.

Fire Studies

Of all the factors operating to destroy southern forests, the most serious is fire. Control of fire is essential to the growing of timber crops in the South as in every forest region of the world. The Station's fire studies are directed toward the solution of problems in the development of (a) improved fire-protection methods; (b) a method of evaluating the effects of fire; and (c) a technique of controlled burning that is both economical and effective. Past work was directed principally to learning the effects of fire and the benefits of fire protection. More recently the Station has been concentrating its efforts on analyzing forest-fire danger and protection needs under varying conditions. Fire danger, as it concerns both the probability of a fire starting and the difficulty of suppressing a fire once started, changes greatly from day to day and even from hour to hour. Maintaining too large a fire-suppression organization is extremely costly, while too small an organization during severe fire conditions may be disastrous. Intensive studies of 300 fires have revealed a close relationship between the rate at which fires spread and the weather and fuel conditions. From these relationships, it has been possible to estimate the size and rate of spread of a fire at any given time under varying conditions of wind velocity, fuel moisture, and age and density of the ground vegetation. For estimating fuel moisture, a special hazard-indicator stick has been developed. Usually a measure of the wind velocity and the fuel moisture is sufficient to predict the size and rate of spread of a fire on any particular forest. Determinations are also being made of the rate at which fires can be extinguished under these same conditions. The relation of probability of fire occurrence to burning conditions has also been studied. The results are being used to provide a basis for planning fire-protection organization and for estimating the size of crew needed on specific fires. As a result, real savings will be possible through reducing the size of fire-fighting organizations during periods when burning conditions are poor. Extra safety is also provided through specified expansion when severe conditions are indicated.

Studies of Forest Influences

In many parts of the South, improper land use has permitted abnormal washing or erosion of sloping lands by rainfall and has transformed hundreds of thousands of acres of what was once fertile agricultural land into eroding wastes, the productive capacity of which has been greatly impaired and in some places destroyed. Rapid run-off of rain water also adds materially to flood problems and constitutes a serious menace to property in many lowland areas. Because of these problems, emphasis in the Station's program of forest-influences research has been placed on developing simple, effective methods of restoring a forest cover on eroded lands, to provide a practicable means of controlling water run-off and conserving soil. Other investigations have dealt with basic factors affecting run-off and associated soil-erosion problems.

In a study of soil and water losses from seven types of cover and land use, representative of the Loessal and upper Coastal Plain regions in northern Mississippi, it was found that barren or cultivated lands lose 4,300 times as much soil as lands protected by forest or grass cover, which absorb practically all the rainfall. In another study in which forest litter was applied to the surface of a compact, eroded subsoil, erosion decreased to negligible proportions, and surface run-off was reduced more than 50 percent. Other studies have demonstrated that annual light surface fires markedly increase surface run-off and erosion from forest and grass land.

One of the main contributions from the Station has been the development of simple techniques for controlling erosion. Station studies have served as a guide to large-scale erosion-control projects demonstrating that trees and other soil-binding plants can be established successfully on gullied lands, using inexpensive check dams and other simple site-improvement measures. For successful planting of impoverished, eroded sites, the Station has found: (1) that top-grade seedlings must be used; (2) that southern pines can be established satisfactorily by planting the trees in holes filled with topsoil, thus dispensing with check dams, bank reduction, and other more expensive preparatory measures; (3) that it is desirable to plow or remove heavy grass before planting black locust, but that similar treatments are unnecessary for shortleaf or loblolly pine; (4) that losses of broadleaf planting stock can be prevented by heeling-in the trees in sand instead of loam; (5) that it is possible to plant rather large black locust stock at little additional expense by drastically pruning the roots. Another Station study has resulted in the development of a cheap, effective seed treatment for black locust, viz., soaking in concentrated sulphuric acid, which in field trials doubled the yields of seedlings.

The control of erosion on roadbanks constitutes a serious problem in the Southern Region and usually requires rather costly remedies. Station studies have shown that eroding cutbanks can be stabilized successfully without reducing them to gentle gradients and without resorting to the more costly sodding methods in everyday use. A special method of preparing and planting banks has been developed that gives greatly superior results to those obtained from the usual method of contour trench planting. This study has shown: (1) that relatively wide spacing of small Bermuda-grass sods or broadcast sowing to seed of several herbaceous species can be relied upon to provide a satisfactory plant cover; (2) that cutbanks should be planted in the spring rather than in the fall, but that sloping and other preparatory work on the banks should be done preferably in the fall; (3) that light top dressing of fertile soil is a minimum requirement in stabilizing cutbanks; and (4) that light applications of fertilizer are also helpful.

Private Forestry Investigations

Ninety-three percent of the commercial forest land and 95 percent of the saw-timber volume in the Station territory are in private ownership. Of this privately owned forest land, over 37 percent is on farms. According to the last Census figures, the forest industries of the South provide employment for about one-fourth of all persons employed in manufacturing industries. Under proper protection and management, the yields from these forest lands could be increased greatly and could support more than 2,000,000 people on a stable and permanent basis. These figures indicate the importance of the private-forestry problem in the South. In fact, the economic and social future of the South is dependent to a very large degree on the productivity of these lands.

To encourage private owners to adopt sustained-yield forest management, the Southern Station is obtaining definite information on costs and returns of timber growing. Through production cost studies and financial analysis, it is developing improved methods of managing and utilizing Southern forests. At present, these studies are centered at Crossett, Arkansas, in the shortleaf-loblolly pine type. One of these studies has shown the economic feasibility of light selective cuttings in virgin pine stands, using railroad logging. Somewhat less than half the saw-timber volume was cut, while about two-thirds of the number of trees of saw-timber size, including the most thrifty individuals, were reserved for future cuts, using 10-year cutting cycles.

Most of the timber in the South, however, is second-growth, and the per-acre volumes of saw timber are too light to make railroad logging profitable. Studies were made, therefore, of selective logging with trucks and with tractors. These showed that cuts as light as 500 board feet per acre are financially feasible, and that costs of logging were much less, and the net return per M board feet much greater for large trees than for small ones. It was also found that the top logs of second-growth trees could be cut more profitably into pulpwood than into sawlogs. The method of selective-timber management with light cuts at 5- to 10-year intervals, as developed by the Station has been adopted successfully by a large number of operators.

New Public Domain

The causes and uses of the South's "new public domain"—the area that has been forfeited to public ownership for non-payment of taxes—are also being studied. In 1934, approximately 31 million acres was found to be in tax-default for 3 or more years; about 17 million acres of this was forest land, or about 14 percent of all the forest land in this region. Station studies indicate that this extensive tax-delinquency of forest land is, in general, the result of one or more of the following: (1) overcutting of the timber resources and subsequent abandonment of the property; (2) poor administration of the tax system; and (3) inequitable taxes.

The remedies lie in improving conditions for private forest operations, placing them on a permanent basis, improving the administration of tax laws, and, where necessary, revising the laws. For lands that no longer can support private operations, the obvious solution is public ownership.

Forest Survey

The Forest Survey of the South was started in 1930. It includes an inventory of the present supplies of standing timber and other forest products, a determination of the rate at which the timber is being increased through growth and diminished through industrial and other uses, and a study of future forest requirements. Its purpose is to supply information needed to formulate a regional policy for the effective and rational use of land suitable for forest production. Field work has now been completed on all except the post oak and cedar-brake regions of Texas and Oklahoma, and computation, interpretation, and publication of results are well under way.

Of 208 million acres of land in the deep South already surveyed, it was found that 122 million acres, or nearly 60 percent of the total area, is forest land. Pines make up about 45 percent of the total cubic volume of sound trees, while hardwoods and cypress comprise the remaining 55 percent.

For four sub-regions of the South, the average saw-timber stand per acre for all conditions from clear-cut to old growth was found to be as follows: pine-hardwood region west of the Mississippi River 2,530 board feet; pine-hardwood region east of the Mississippi River 2,340 board feet; naval stores region 1,500 board feet; and Mississippi Delta region 2,530 board feet.

An enumeration of the sawmills in the deep South showed that there were 8,205 known mills more or less active in 1936. Of these, 7,565, or more than 92 percent, were small mills with a capacity under 20 M board feet per day. Large mills are gradually decreasing in number, and small mills are becoming increasingly important in lumber production. In 1934, small mills produced 47 percent of the pine lumber cut.

The rapid expansion of the pulp and paper industry in the South has nearly doubled the capacity of its pulp mills since 1935. Another step in this expansion is proposed in east Texas, where plans are being made to erect a mill to make newsprint from southern pine—the first mill of its kind in the South. Most of the southern pine pulp mills operate by the sulphate process, which makes paper for bags, wrappers, and container boards. A few mills, including the one at Houston, Texas, make bleached sulphate pulp, which goes into white paper.

The relationship between forest growth and drain is constantly changing, as is illustrated by data for northeast Texas. At the beginning of 1935, this survey unit of 8½ million acres had approximately 1,740,000,000 cubic feet of pine growing stock. During 1935 and 1936, the increment slightly exceeded the drain, so that by the first of 1937 the growing stock had increased about 20,000,000 cubic feet. During this same period, however, the drain also increased and for 1937 exceeded the growth by about 3,500,000 cubic feet. Such fluctuations in the cut of forest products emphasize the need for keeping this information up to date. In 1935, in the southeast Texas survey unit covering nearly 10 million acres, there was an increment of about 303,000,000 cubic feet for all species, or slightly more than double the drain for all purposes.

The east Texas post oak belt—a region of about 12,000,000 acres lying between the east Texas pine belt and the "black prairie" country—has a forest area of about 3,600,000 acres, constituting 29 percent of the total land area. Approximately 93 percent of this forest is in the post oak type, which is chiefly of local value for cordwood and other domestic farm uses. Four percent is in hardwood types, which produce material of commercial saw-timber quality; these types occur in the river bottoms and on some of the better upland soils. The remaining 3 percent is in pine and cedar.

Summary

In this paper, I have summarized a few of the results of research conducted by the Southern Forest Experiment Station. We all recognize the desirability of promoting the full use of the immense area of forest land in this southern region, most of which is now utilized but partially. The findings of the Southern Station are made available currently to interested agencies throughout the South, which in turn disseminate the information to forest landowners. Progress reports are made public by the Station in "Occasional Papers", "Survey Releases", and technical journals, whereas final reports are printed in Washington. The application of the methods recommended by the Station, which must be made by the landowners and managers themselves, should result in a more diversified use of the forests, more permanent communities and industries, a more permanent employment of labor, more prosperous railroads and other utilities, a broader and more stable tax base, and a better standard of living for the people of the South. In the meantime, the program of the Southern Station will continue to be directed towards helping the South attain the full opportunities offered by its most valuable natural resource—its forests.

OCCASIONAL PAPER NO. 78 DECEMBER 8, 1938

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New Orleans, La.

PRELIMINARY INVESTIGATIONS ON DRY, COLD STORAGE OF SOUTHERN PINE SEED

by

Mary L. Nelson, Junior Plant Physiologist, CCC
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

PRELIMINARY INVESTIGATIONS ON DRY, COLD STORAGE OF SOUTHERN PINE SEED

by

Mary L. Nelson, Junior Plant Physiologist, CCC,
Southern Forest Experiment Station

Adequate methods of maintaining a high degree of viability in southern pine seed during storage are urgently needed. The Federal nurseries in the South use annually about 15 tons of southern pine seed, State and private nurseries use many more tons, and an increasing demand is in prospect. The annual collection of such quantities of seed is difficult or impossible, however, because the production of good seed crops by southern pines varies greatly with the season and the locality. The following tabulation of the longleaf cone crops for 2 successive years emphasizes this point:

Locality	1935 crop[1]	1936 crop[2]
Southern South Carolina	Fair to good	Definitely poor
Central and south Georgia	Good	Poor to spotty
Florida	Local variations extreme	Definitely poor
Central and south Alabama	Fair to good	Poor to spotty
South and southeast Mississippi	Very heavy	Poor to spotty
Southeast Louisiana	Very heavy	Poor to spotty
Central Louisiana	Very heavy	Definitely poor
East Texas	Very heavy	Poor to spotty

In years when the crop is a failure in one place but good in another, the deficit might be made up in one region by obtaining seed from an area of heavy production, but it is becoming increasingly evident that in many places local strains of forest trees are better for planting than those imported from a distance. This places a premium on local seed and emphasizes the need for storage methods that will maintain high viability in the large quantities of seed collected locally in years of good production.

There are in the files of the Southern Forest Experiment Station, and to a less extent in scattered publications, the results of several "exploratory" storage tests of southern pine seed. Pending publication of more comprehensive studies, the information obtained from these preliminary studies should be of interest and in some instances of direct practical benefit to individuals and agencies confronted with seed-storage problems. In the CCC program in particular, it is imperative that costly and meager supplies of seed be conserved by correct methods of storage. It is the purpose of this paper, therefore, to evaluate the results of the Station's storage tests and to compare them with results obtained by other workers, so that they may be available for immediate use. Results of early work on storage of southern pine seed are presented in considerable detail because it is thought that users of seed will find these details very illuminating.

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[1] Wakeley, Philip C. Estimate of the 1935 cone crop of southern pines. Southern Forest Experiment Station. (Mimeographed) August 27, 1935.

[2] Wakeley, Philip C. Estimate of the 1936 cone crop of southern pines. Southern Forest Experiment Station. (Mimeographed) August 22, 1936.

For several reasons, most emphasis has been placed on methods of storing longleaf pine seed. Because of the relatively small number of seed per pound in this species, any reduction in germination percentage results in a disproportionately great increase in the cost per thousand of seedlings produced. With longleaf seed at $1.00 a pound, a rather common price, the cost per thousand trees for seed alone rises from $0.36 if 70 percent of the seed produce seedlings, to $0.63 per thousand if the seed viability drops to 40 percent, and to the astounding figure of $2.50 per thousand trees if effective germination is only 10 percent. Nevertheless, longleaf seed is particularly likely to deteriorate in storage.

Early attempts at the Southern Forest Experiment Station to store southern pine seed made use of a variety of containers, such as sealed glass jars, paper bags, and even sealed wax-paper bags. Some seed lots were disinfected with formaldehyde, other lots were untreated. No record was made of the moisture content of the seed at time of storing, nor was the germination percentage (measure of initial seed quality) always determined for the fresh seed. Temperatures during the storage period were disregarded. A concise, quantitative summary of experiments during this early period cannot be made, but the nature of the results is readily apparent when the data are grouped loosely by species and by treatment previous to storage. The results were highly erratic and generally unsatisfactory (see table 1). The viability of longleaf seed was usually greatly reduced within a year. For instance, the germination percentage of a longleaf seed lot dropped in 1 year from an initial value of 49 percent to 14 percent when stored, without disinfection, in sealed glass; yet the following season, the germination percentage of a lot under comparable storage conditions with 77 percent initial germination dropped in 1 year to 2.4 percent. On the other hand, longleaf seed from the 1925 crop, with a germination of 75 percent when fresh, when stored in sealed glass after treatment with formaldehyde kept remarkably well for 1 year (germination 74.0 percent) and moderately well for 2 years more (41.5 percent and 42.8 percent germination after 2 and 3 years, respectively). Since the longleaf seed were usually dried by air currents from an electric fan after treatment with formaldehyde, it was thought that this thorough drying might have been the factor responsible for the good preservation of these seed lots. This led to measurements of seed moisture content before storage, and in 1935 a cautious surmise was expressed (3)[3] that moisture content was important in the storage of longleaf pine seed.

Slash and loblolly seed in various containers gave somewhat erratic results—in general, rather poor—but this cannot be attributed entirely to the storage methods, as the germination periods in successive years were of unequal length. Both slash and loblolly seed tend to become dormant, and to require long periods for complete germination, but they nevertheless remained viable longer than longleaf seed. This tendency of the smaller seed to keep better than the larger ones was another clue to the possible importance of moisture content, since the proportion of hard, dry seedcoat to moist kernel is greater in small seed and therefore the moisture content of the seed is lower.

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[3] Figures in parentheses refer to Literature Cited, page 19.

Table 1. - Summary of results of storage in various containers and at uncontrolled temperatures as shown by best available germination tests (1922-25)

Cone sublot no.	Storage method	Germination medium	Percent of germination[1]					
			Fresh	Years in storage				
				1	2	3	4	5
		LONGLEAF						
– 1922	Sealed glass-2nd year	Sand & soil		5.0				
		Sand			0.0			
5 1924	Sealed glass, not disinfected[2]	Sand & soil	49.0					
		Sand		14.0				
		Sand			0.3			
5 1924	Unsealed paper, not disinfected	Sand & soil	49.0					
		Sand		19.0				
		Sand			0.0			
		Paper towel				0.0		
5 1924	Sealed glass, formaldehyde	Sand & soil	49.0					
		Sand		36.0				
		Sand			6.2			
5 1924	Paper bag, formaldehyde	Sand & soil	49.0					
		Sand		15.5				
5 1924	Sealed wax paper, not disinfected	Sand & soil	49.0					
		Sand		14.0				
		Sand			5.5			
		Paper towel				0.0		
2a 1925	Sealed glass, formaldehyde	Sand	75.0					
		Sand		74.0				
		Paper towel			41.5			
		Sand				42.8		
		Sand					0.0	
		Sand						0.0

(Continued on following page)

Table 1. - Summary of results of storage in various containers and at uncontrolled temperatures as shown by best available germination tests (1922-25) - Cont'd.

Cone sublot no.	Storage method	Germination medium	Percent of germination[1]					
			Fresh	Years in storage				
				1	2	3	4	5
		LONGLEAF (Cont'd.)						
2a 1925	Sealed glass, not disinfected	Sand	77.0					
		Sand		2.4				
		Paper towel			0.0			
		Sand				0.0		
		Sand					0.0	
		Sand						0.0
2a 1925	Unsealed ash can	Sand	77.0					
		Sand		3.2				
		Paper towel			0.0			
2a 1925	Unsealed paper	Sand	77.0					
		Sand		2.8				
		Paper towel			0.0			
2a 1925	Buried 2½ feet deep	Sand	77.0					
		(None[3])		-				
		SLASH						
- 1922	Sealed glass	Sand			0.0			
- 1923	Sealed glass	Sand		24.0				
		Jacobsen			5.0			
		Compost				6.2		
- 1924	Sealed glass, not disinfected	Sand		66.0				
		Compost			1.0			
- 1924	Paper bag, not disinfected	Sand		61.0				
		Compost			2.3			
		Paper towel				0.0		
- 1924	Sealed glass, formaldehyde	Sand		63.0				
		Compost			8.8			
- 1924	Paper bag, formaldehyde	Sand		71.0				

(Continued on following page)

Table 1. - Summary of results of storage in various containers and at uncontrolled temperatures as shown by best available germination tests (1922-25) - Cont'd.

Cone sublot no.	Storage method	Germination medium	Percent of germination[1]					
			Fresh	Years in storage				
				1	2	3	4	5
		SLASH (Cont'd.)						
– 1924	Unsealed ash can	Sand		66.0				
		Compost			3.8			
		Paper towel				1.0		
– 1924	(Spring, 1925) Ash can, commercial storage	Sand		64.0				
– 1924	Sealed wax paper	Sand		71.0				
		Compost			1.4			
		Paper towel				0.0		
		LOBLOLLY						
– 1922	Sealed glass	Sand			20.0			
– 1923	Sealed glass	Sand		13.0				
		Jacobsen			2.0			
		Sand				0.0		
– 1923	Paper sack	Sand		58.0				
		Sand			40.0			
		Sand				3.7		
– 1923	Unsealed ash can	Sand			44.0			
		Sand				8.5		
		Paper towel					0.0	
– 1924	Sealed glass, not disinfected	Sand	48.0					
		Sand		13.0				
		Sand			0.0			
– 1924	Paper bag, not disinfected	Sand	48.0					
		Sand		19.0				
		Sand			0.4			
		Paper towel				0.0		
– 1924	Sealed glass, formaldehyde	Sand	48.0					
		Sand		14.0				

(Continued on following page)

Table 1. - Summary of results of storage in various containers and at uncontrolled temperatures as shown by best available germination tests (1922-25) - Cont'd.

Cone sublot no.	Storage method	Germination medium	Percent of germination[1/]					
			Fresh	Years in storage				
				1	2	3	4	5
		LOBLOLLY (Cont'd.)						
–	Paper bag,	Sand	48.0					
1924	formaldehyde	Sand		11.0				
–	Sealed wax paper,	Sand	48.0					
1924	not disinfected	Sand		20.0				
		Sand			0.0			
		Paper towel				0.0		
42h	Sealed glass,	Sand	57.0					
1925	not disinfected	Sand		31.6				
		Paper towel			1.5			
		Sand				12.0		
		Sand					0.0	
		Sand						0.0
42h	Paper bag,	Sand	57.0					
1925	not disinfected	Sand		43.8				
		Paper towel			16.0			
42h	Sealed glass,	Sand	57.0					
1925	formaldehyde	Sand		25.6				
		Paper towel			8.5			
		Sand				24.0		
		Sand					12.0	
		Sand						3.0
42h	Unsealed ash can	Sand	57.0					
1925		Sand		46.2				
		Paper towel			10.0			
		SHORTLEAF						
–	Sealed glass	Sand		10.0				
1923		Jacobsen			3.0			
		Soil				1.4		
3	Unsealed paper	Jacobsen	33.0					
1924	sack	Sand		17.0				
		Soil			0.0			
		Paper towel				0.0		

(Continued on following page)

Table 1. - Summary of results of storage in various containers and at uncontrolled temperatures as shown by best available germination tests (1922-25) - Cont'd.

Cone sublot no.	Storage method	Germination medium	Percent of germination[1]					
			Fresh	Years in storage				
				1	2	3	4	5
		SHORTLEAF (Cont'd.)						
62h 1925	Sealed glass, not disinfected	Sand	82.0					
		Sand		63.6				
		Paper towel			0.0			
		Sand				0.0		
		Sand					0.0	
		Sand						0.0
62h 1925	Paper sack, not disinfected	Sand	82.0					
		Sand		47.0				
		Paper towel			2.0			
62h 1925	Sealed glass, formaldehyde	Sand	82.0					
		Soil		30.8				
		Paper towel			32.0			
		Sand				30.0		
		Sand					3.0	
		Sand						4.0
62h 1925	Unsealed ash can	Sand	82.0					
		Sand		39.4				
		Paper towel			1.5			
62h 1925	Sealed wax paper	Sand	82.0					
		Soil		13.0				
		Paper towel			1.5			

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[1] Germination percentage is based on all seed sown, as cutting tests of ungerminated seed were lacking in many instances. Length of germination periods varied from 33 to 150 days; in all cases, tests were run longer than necessary for essentially complete germination.

[2] The annotations "formaldehyde" and "not disinfected" indicate, respectively, samples rinsed in weak formaldehyde solution before storing, and matched samples stored without disinfection as checks. Lack of annotation indicates that the sample was neither treated nor matched with a treated sample.

[3] Seed decayed during first year; no germination tests made.

The first consistent successes in maintaining viability of longleaf seed resulted from holding the samples in cold storage. Seed held in a sealed glass jar under refrigeration gave as high germination at the end of 2 years as when fresh, whereas the same seed stored at room temperatures, in a variety of containers, and after several types of disinfection, were much reduced in viability after 1 year and were completely spoiled at the end of 2 years. The details of storage and percentages of germination are given in table 2, which also gives the data on lots stored in an ordinary ice box (at about 55° F.), in a commercial fish-packing plant (cooled by ice), and in a mechanical refrigerator. The seed containers were of various types: sealed glass jar, semi-sealed jar, screw-top can, and paper sack. Results at the end of a year were uniformly good. Cold-storage seed lots tested in 1936 and 1937 were obtained from Federal and State forest nurseries; these had usually been stored in commercial cold-storage warehouses. Data on storage containers and temperatures are meager, and the germination percentages of the fresh seed were usually not available, but the generally good condition of the seed after 1-3 years is apparent.

The preservative value of low temperatures is further borne out by a report[4] of successful storage of longleaf pine seed in air-tight jars, for 1-3 years, in a fairly cool basement at the Institute of Forest Genetics at Placerville, Calif.

Longleaf pine seed stored in paper bags in a refrigerated room at the Lake States Forest Experiment Station in 1929-30 (sample number 12, 1929, table 2) gave higher germination at the end of a year than a portion of the same seed lot stored in a sealed glass jar (sample number 10, 1929, table 2). It has been predicted that the reverse would happen, because the drying effect of the refrigeration room on the seed exposed in a paper sack was thought to be harmful. Since the thoroughly dried seed kept better, the moisture content during storage was again thought to be an important factor.

The data in table 2 do not prove or disprove the adequacy of a cold environment as a storage method, because of the lack of experimental design, matched samples for different treatments, or an attempt at check or control lots. Table 2 does, however, contain valuable contributory evidence on the subject, since it does show a noteworthy number of seed lots held at low temperatures that were good after 1 or more years.

A much more systematic and detailed test of low-temperature versus air-temperature storage, over a period of 6 years, showed conclusively that cold storage was effective in maintaining viability of longleaf, slash, loblolly, and shortleaf seed (table 3). The seed were stored in semi-sealed glass jars in lots of approximately 750-1,000, at room temperature and at 33°-35° F. A separate jar was put up for each year of testing, so that conditions within the jar would not be changed by admission of air during withdrawal of the test sample. The prevailing high germination values for the cold-storage lots of all species, and the practically complete failures of all the room-temperature lots after 2 years in storage, demonstrated conclusively the beneficial effects of storage at low temperature.

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[4] In a letter from Lloyd Austin, Director, Institute of Forest Genetics, to Philip C. Wakeley, August 23, 1933.

Table 2. - Tests showing the effects of cold storage for one or more years

Seed sample number	Storage temperature and environment	Container	Germination percent			
			Fresh	Years of storage		
				1	2	3
		LONGLEAF				
[1] 1927						
(9	Normal room	Unsealed ash can	76.5	52.0	2.0	0.0
(10	Normal room	Sealed glass jar	76.5	16.0	0.0	0.0
(11 (	25°-30° F. (Mechanical refrigeration)	Sealed glass jar	76.5	75.8	77.6	(Seed stolen)
(12	Normal room	Sealed glass jar[2]	76.5	(Spoiled)	-	-
(13	Normal room	Sealed glass jar[3]	56.5	26.8	0.4	-
(14	Normal room	Sealed glass jar[4]	60.0	9.4	0.0	0.0
1928						
(27 (	About 55° F. (ice box)	Screw-top can	73.5	67.6	66.5	-
(28	Normal room	Unsealed ash can	76.0	26.8	0.0	-
1929						
(10 (	32° F. (Mechanical refrigeration)	Sealed glass jar	55.6	54.8	-	-
(11	Normal room	Sealed glass jar	55.6	47.6	-	-
(12 (	32° F. (Mechanical refrigeration)	Paper sack	55.6	60.0	-	-
(13	Normal room	Paper sack	55.6	26.0	-	-
(21 ((	Ice refrigeration (Fish packing plant)	Can	49.2	45.0	-	-
(21	Normal room	Unsealed ash can	49.2	0.0	-	-
(23 ((	Ice refrigeration (Fish packing plant)	Can (?)	46.8	35.0	-	-
(23	Normal room	Paper sack	46.8	0.0	-	-
1936						
1502	Cold storage (State nursery)	-	-	-	64.0	-
1503	Cold storage (State nursery)	-	-	39.2	-	-
1506	Cold (Federal nursery)	Galvanized iron can	-	41.5	27.8	-
1507	Cold (Federal nursery)	-	-	5.9	-	-

(Continued on following page)

Table 2. - Tests showing the effects of cold storage for one or more years - Cont'd.

Seed sample number	Storage temperature and environment	Container	Germination percent			
			Fresh	Years of storage		
				1	2	3
		LONGLEAF (Cont'd.)				
1937						
1515	Cold (Federal nursery)	Galvanized iron can	73.0	52.7	-	-
1516	Cold (Federal nursery)	Galvanized iron can	-	28.5	-	-
		SLASH				
1930						
145a	34°-40° F.	Air-tight friction-top tin	-	79.6	-	-
1936						
2501	Cold (State nursery)	-	-	-	65.2	60.8
2502	Cold (State nursery)	-	-	52.8	-	-
2505	38° F. (Federal nursery)	Galvanized iron can	-	84.8(?)	70.3	71.7
2506	38° F. (Federal nursery)	Galvanized iron can	-	55.1	-	-
2507	Cold (Federal nursery)	-	-	72.4	-	-
1937						
2506	Cold (Federal nursery)	Galvanized iron can	80.7	70.3 (Strat.)	-	-
2504	Cold (Federal nursery)	Galvanized iron can	-	-	-	71.7
2504	Cold (Federal nursery)	Galvanized iron can	-	-	-	72.2 (Strat)
		LOBLOLLY				
1936						
3501	Cold (State nursery)	-	-	-	40.8	-
3502	Cold (State nursery)	-	-	44.8	-	-
3506	Cold (Federal nursery)	-	-	68.8	-	-
1937						
3509	Cold (Federal nursery)	-	-	42.4	-	-
3510	Cold (Federal nursery)	-	-	59.2	-	-

(Continued on following page)

Table 2. - Tests showing the effects of cold storage for one or more years - Cont'd.

Seed sample number	Storage temperature and environment	Container	Germination percent			
			Fresh	Years of storage		
				1	2	3
		SHORTLEAF				
1930 301	34°-40° F.	Air-tight, friction-top tin	-	86.0	-	-
1937 (4510 (	30° F. (Federal nursery)	Sealed can	64.0	-	56.0	-
(4511 (	Seed room (Federal nursery)	Mason jar	64.0	-	60.8	-

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[1] Brackets indicate samples drawn from the same original seed lot, and therefore comparable until treated as indicated in the table.

[2] Seeds were packed in sphagnum moss moistened with approximately 1/20 normal salicylic acid solution.

[3] Jars and seed were sterilized with DuPont Semesan, 33 mg. to approximately 80 g. of seed.

[4] Jars and seed were sterilized with formaldehyde (3/10 percent or 1 fluid ounce per gallon of water for 10 minutes). Seeds were then dried with an electric fan.

Table 3.- Germination percentages of initially comparable samples[1] of longleaf, slash, loblolly, and shortleaf pine seed kept in semi-sealed containers in cold storage and at room temperature for 1 to 6 years

Years stored	Date test set up	Total percent germination[2]		Percentage sound at end of test		Total,% germinated plus % sound		Days duration of test	
		Cold	Air	Cold	Air	Cold	Air	Cold	Air
				Longleaf					
0	Mar. 15, 1932	55.6	55.6	0.4	0.4	56.0	56.0	50	50
1	Mar. 6, 1933	41.2	8.8					45	45
2	(Test omitted)								
3	Dec. 3, 1934	61.6						46	
4	Apr. 23, 1936	26.0	0.0	0.0		26.0		70	
5	Jan. 8, 1937	48.0	0.0	0.8	0.0	48.8	0.0	67	67
6	Nov. 15, 1937	46.0	0.0	0.4	0.0	46.4	0.0	80	80
				Slash					
0	Mar. 15, 1932	71.2	71.2	18.4	18.4	89.6	89.6	50	50
1	Mar. 6, 1933	85.2	49.6					35	45
2	(Test omitted)								
3	(Nov. 28, 1934 (Dec. 3, 1934	95.6	0.4	0.4		96.0		>94	
4	Apr. 23, 1936	56.4	0.0	28.8		85.2		69	
5	Jan. 8, 1937	95.6	0.0	0.4	0.0	96.0	0.0	160	160
6	Nov. 15, 1937	93.2	0.0	3.2	0.0	96.4	0.0	125	125
				Loblolly					
0	Mar. 15, 1932	4.0	4.0	81.2	81.2	85.2	85.2	50	50
1	Mar. 6, 1933	4.8	1.2					35	35
2	(Test omitted)								
3	Dec. 3, 1934	64.8		14.8		79.6		>94	
4	Apr. 23, 1936	43.2	8.4	25.2		68.4		69	64
5	Jan. 8, 1937	73.2	0.4	8.4	1.2	81.6	1.6	200	200
6	Nov. 15, 1937	71.6	0.4	7.2	0.0	78.8	0.4	125	125
				Shortleaf					
0	Mar. 15, 1932	68.8	68.8	26.8	26.8	95.6	95.6	50	50
1	Mar. 6, 1933	61.6	56.8					45	45
2	(Test omitted)								
3	(Nov. 28, 1934 (Dec. 3, 1934	94.4	0.8	0.8		95.2		>94	
4	Apr. 23, 1936	78.8	0.0	10.8		89.6		69	
5	Jan. 8, 1937	81.6	0.0	10.4		92.0		67	60
6	Nov. 15, 1937	86.8	0.0	5.2	0.0	92.0	0.0	80	80

1/ Original seed sample numbers: Longleaf, 1001C, 1931; Slash, 2001C, 1931; Loblolly, 3001C, 1931; Shortleaf, 4001C, 1931.

2/ Each figure represents the result of a 250-seed germination test on a "standard" peat mat, without pretreatment of the seed. The laboratory environment (daily temperature range, amount of light, etc.) was not uniform-note various dates of testing.

In this test the percentages obtained from cold-storage seed in the 4th year were below those obtained in the 3d and 5th years, possibly owing to the fact that the seed were tested late in April instead of earlier in the spring. Samples of the 1927 longleaf seed crop, withdrawn from storage at room temperature at monthly intervals and tested in sand, declined sharply in viability at the end of May (table 4). Part of the longleaf seed of the 1928 crop, as shown in table 5, was stored, as in 1927, in paper sacks in a covered can at room temperature, and part was stored in screw-top metal cans in an ice box. Pairs of samples were withdrawn and germinated at monthly intervals for 13 successive months. Since both room-temperature and cold-storage lots show the same sharp decline in total germination between the May and June tests, it seems likely that the low germinability of the 4th-year sample of the 6-year storage test was due to testing late in the season. This brings out the fact that to obtain entirely comparable results in storage studies, yearly germination tests in ordinary laboratories must be run not only on the same type of medium but also at approximately the same season of the year.

The criticism may be raised that the high germination percentages shown in table 3 for seed held in cold storage were obtained only after germination periods as long as 125, 160, and 200 days. Since this experiment was started, however, it has been shown definitely that moist, cold stratification before sowing ordinarily will enable similar dormant seed to germinate almost, if not quite, as rapidly as fresh seed. The use of moist, cold stratification was considered for the later tests of the series, but was finally omitted in order to continue the tests by means of the same germination technique used at the start. The significant fact is not that the seed held at cold storage required 100 or more days to germinate, but that it finally attained a high percentage of germination, while seed stored at room temperature and then exposed to a similar environment for an equally long period failed to germinate.

The next advance in seed-storage methods was the regulation of moisture content of the seed. This varies considerably under different conditions, especially in longleaf pine (table 6); seed freshly dissected from ripe (but unopened) cones may contain as much as 40 percent moisture, based on dry weight, seed that have fallen from cones opened naturally by air-drying are still very moist, and seed from cones opened by kiln-drying also may be surprisingly moist. Several investigators have worked on the influence of this factor on keeping qualities and germination. Coile (2), using closed chambers whose atmospheres were held at constant relative humidities by means of solutions of different concentrations, brought slash pine seed to moisture contents of 7.5, 11.5, 22.5, and 32 percent. At the end of storage for 1 year at room temperature in sealed glass tubes, the lots at 32 and 22.5 percents were covered with molds and failed to germinate; that at 11.5 percent gave 57 percent germination in 40 days; and that at 7.5 percent gave 82 percent germination in 20 days. Barton (1), working with longleaf, slash, loblolly, shortleaf, and other pines, found that in some instances thorough air-drying of seed, together with sealed storage at low temperatures, was effective in maintaining viability for as much as 7 years. Artificial desiccation with calcium oxide was ineffective or harmful; but storage under vacuum was favorable to retention of viability even at room temperature.

Table 4.- Germination tests of longleaf pine seed (1927 crop, cone sublot 1a) removed from air temperature storage at monthly intervals

Storage[1] (months)	Date tested	Germination[2]		
		Final percentage		Days of test
		All seed	Full seed	
1	Dec. 1927	66.5	-	21
3	Feb. 1928	76.5	84.5	30
4	Mar. "	69.0	83.1	30
5	Apr. "	74.4	87.6	25
6	May "	68.9	80.4	35
7	June "	22.7	24.0	30
8	July "	12.0	14.5	35
9	Aug. "	14.0	15.3	30
10	Sept. "	9.6	9.6	29
11	Oct. "	23.0	26.0	30
12	Nov. "	25.5	26.4	24
13	Dec. "	20.0	21.5	29

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[1] Stored in paper sacks in unsealed galvanized iron ash can.

[2] Tested at Southern Forest Experiment Station, in standard sand flats. Each monthly test consisted of 200 seed.

Table 5. - Parallel germination tests of longleaf pine seed (1928 crop)[1] removed at monthly intervals from cold and from air temperature storage

Storage period (months)	Date test set up	Final germination percentage[2]				Days of test	
		All seed		Full seed			
		Cold[3]	Air[4]	Cold[3]	Air[4]	Cold[3]	Air[4]
0	Nov. 20, 1928	-	59.2	-	72.9	-	30
1	Dec. 31, 1928	78.0	74.5	89.6	85.6	22	25
2	Jan. 31, 1929	73.5	76.0	89.1	84.9	27	20
3	Feb. 28, "	73.5	71.0	85.0	85.0	22	20
4	Apr. 6, "	66.0	70.0	67.3	71.8	30	30
5	Apr. 30, "	73.5	65.0	81.7	76.9	35	35
6	May 31, " June 1, "	28.0	12.0	29.0	12.8	36	40
7	July 1, "	19.5	5.0	21.1	5.9	44	40
8	July 31, "	27.5	25.5	28.3	29.1	54	55
9	Sept. 4, "	52.5	25.0	57.7	26.3	51	55
10	Oct. 3, "	70.0	37.5	73.6	38.5	49	55
11	Oct. 31, "	77.5	43.5	86.1	48.6	42	50
12	Dec. 2, "	65.5	26.0	71.8	26.7	31	45
13	Jan. 21, 1930	67.6	26.8	74.5	28.4	38	60

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[1] Cone sublot 2a, 1928, seed samples 27 (cold storage) and 28 (air temperature storage), 1928.

[2] Tested in standard sand flat, 200 seeds each test (except 250 seeds for Jan. 21, 1930 test of cold storage seed).

[3] In screw-top soil cans in domestic ice box, at approximately 55° F.

[4] In paper sacks in unsealed galvanized iron can, at room temperature.

Table 6.- Moisture content of longleaf pine seed

Extraction and treatment of seed	Percent moisture (based on dry wt.)		Basis
	Whole seed	Kernel only	
Cones freshly collected, seed dissected out	40.7	64.5	10 seed
Seed dissected out several days after collection	35.3	49.2	10 seed
Cones air-dried for 2 weeks after collection	29.8	39.5	10 seed
Cones air-dried; moisture content determined upon release of seed from cones	(28.9 (28.0 (25.5	35.9 38.6 33.5	11 seed 19 seed -
Cones air-dried at nursery	19.5	-	4 lots
Cones air-dried, seed air-dried 30 days	11.1	12.6	10 seed
Cones kiln-dried (130° F.), seed dewinged	15.7	-	4 lots
Cones kiln-dried (130° F.), seed with wings on	20.0	-	4 lots
Cones kiln-dried ("Charge 83")	21.2	-	4 lots
Cones kiln-dried	20.4	-	4 lots[1]
Cones kiln-dried; seed tested at beginning of storage study	(22.5 (22.6	- -	4 lots[1] 4 lots[1]
Cones kiln-dried; seed used to pack cans and bags in storage study (dewinged	14.6	-	4 lots[2]
(wings on	16.1	-	4 lots[2]
Cones kiln-dried; seed stored in can (bottom	25.6	-	1 lot[3]
(middle	23.8	-	1 lot[3]
(middle	22.9	-	1 lot[3]
(top	26.9	-	1 lot[3]
(mixed	25.9	-	1 lot[3]
Seed used in storage study (1927)	11.5	-	-
Cones kiln-dried (130° F.); seed redried in kiln	8.4	-	4 lots

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[1] 100 seed each.
[2] 10 grams each.
[3] 50 grams.

Some nurserymen in Georgia have followed the practice of sunning their sacks of fresh seed 2 or 3 days a week from the time of extraction to the middle of March, then pouring the seed into carefully cleaned empty grease cans, screwing the tops on securely, and storing in pecan (cold-storage) warehouses. Both longleaf and slash pine seed have kept well for 2 years following this treatment.

Subsequent experiments at the Southern Station, to be described in detail in a forthcoming publication, have confirmed the beneficial effects on storage of longleaf seed of low temperature and low moisture content. The most significant single factor, as revealed by these tests, was moisture content; environment, of which cold storage was one type, was of secondary importance.

A small study was run in 1936-37 to determine seed deterioration at several degrees of wetness. Paired samples of longleaf seed with initial germination of 77.3 percent were reduced by air drying to five different moisture contents from about 22 percent to about 6 percent, as shown in table 7. One series of these samples was stored in sealed glass jars at room temperatures, and the other series at 38° F. At the end of 1 year, germination tests were made. The samples stored at room temperature, and having a moisture content of at least 9.5 percent, were almost or entirely spoiled, but the sample at 6 percent gave 48.8 percent germination, which was surprisingly good. This behavior is similar to that of the longleaf seed lots put up in 1925, and mentioned earlier in this discussion. In the 1925 series (table 1) the lots stored without extra drying in an unsealed ash can, in sealed glass (not disinfected), and in a paper sack were almost entirely spoiled in 1 year, just as were the 1936 lots having moisture contents of 9.5 percent or above. The lot treated with formaldehyde, and well dried before sealing in a glass jar, was in excellent condition after storing 1 year; in fact, it was more viable than the 1936 lot dried to 6 percent moisture content.

Of the samples in the 1936 series stored at 38° F., the three at the higher moisture contents were not entirely comparable with the others because they were not placed in cold storage immediately after sealing in jars. The sample at 9.5 percent germinated 56.8 percent, and the one at 6 percent germinated 66.4 percent, or almost as well as the fresh seed. The most interesting feature of the test was the retention of high viability of the seed at 6 percent, both at room temperature and in the cold.

The conclusions to be drawn from these (preliminary) studies and observations are: (1) that a reduction in seed moisture content by methods that will not injure the seed (e.g., by air-drying before a fan or in the sun) is distinctly beneficial in maintaining seed viability; and (2) that storage at low temperatures (approximately 30°-40° F.) also aids materially in preventing seed deterioration. The object of later experiments will be to delimit more closely the optimum ranges of moisture content and of low temperature, and to test the possibilities of combining the two; but until results of such experiments are available, the data embodied in this report should serve to point the way towards better storage methods.

Table 7.- Effect of moisture content upon keeping quality of longleaf pine seed held in sealed glass jars at room temperature and in cold storage

Initial moisture content, percent	Germination percentage[1] after approximately 10 months at:-	
	Room temperature	38° F.
21.97	0.0	(12.4)[2]
17.85	0.0	(34.8)[2]
12.61	0.0	(59.6)[2]
9.50	0.8	56.8
6.02	48.8	66.4

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[1] Germination percentage before samples were dried and stored was 77.3%.

[2] Held in sealed jars at room temperature for 8 to 15 days before being placed in refrigerator—hence not strictly comparable with other seed lots.

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OCCASIONAL PAPER NO. 79 JANUARY 9, 1939

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SOUTHERN FOREST EXPERIMENT STATION

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COSTS AND RETURNS OF MANAGING 100,000 ACRES OF SHORTLEAF AND LOBLOLLY PINE FOR SUSTAINED YIELD

by

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Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

COSTS AND RETURNS OF MANAGING 100,000 ACRES OF SHORTLEAF AND LOBLOLLY PINE FOR SUSTAINED YIELD

By W. E. Bond,
Senior Forest Economist,
Southern Forest Experiment Station

Satisfactory commercial forest management not only must produce continuous yields of merchantable forest products but also it must produce them with a reasonable margin of returns over costs. During recent years several large companies in the South have insured the permanence of their operations by adopting sustained-yield forest management. These operations have not progressed far enough to disclose the ultimate financial possibilities of this type of management, but present studies of costs and returns indicate that it is economically practical and financially attractive.

The purpose of this paper is to show the financial possibilities of managing existing large properties, composed chiefly of second-growth shortleaf and loblolly pine, for sustained yield, starting with unmanaged natural stands. A property of over 100,000 acres in the Upper Coastal Plain has been selected as an illustration, and the costs and returns of sustained-yield management over a period of 30 years have been estimated. The forest types and conditions that comprise this forest, and the area, volume of stands, and increment in each type and condition, have been determined by a line-plot survey, although some of the minor types have been combined and the areas of the different classes of timber have been changed sufficiently to maintain secret the identity of the property.

When available, the costs and returns computed in this paper are those actually applying to the 100,000 acres and when not available, they were obtained from economic investigations of private forestry under similar forest and economic conditions. Although the computed costs and returns are better than those obtained from average forest stands of the Upper Coastal Plain, they are nevertheless conservative and can be obtained on many large properties under present economic conditions. It should be clearly understood, however, that the figures given apply to the property described and can not be applied safely to other properties without taking into consideration the volume and growth of the growing stock, productive capacity of the site, and available markets.

Lumbering operations have been conducted continuously on this property for more than 30 years. During the early part of this period only the largest and best trees were cut, but during the greater portion of the period practically all merchantable trees at least 10 inches in diameter at breast high (d.b.h.) were removed. A few years ago, minimum diameter limits of 14 inches for pine and 16 inches for hardwoods were adopted, and 2 years ago selective cutting was put into practice. All trees are now marked by an experienced man before cutting. Reasonably good fire protection has been practiced for about 13 years, resulting in excellent stands of reproduction and saplings. Most parts of the property are accessible to trucks over improved public or ungraded community roads, and during the past few years additional roads built by the CCC have made truck logging much more economical than previously.

Growing stock and growth

About 70 percent of the forest property here discussed is occupied by second-growth pine stands, in which loblolly pine makes up about two-thirds and shortleaf pine about one-third of the volume. The remaining 30 percent of the area is occupied by old-growth pine, old-field pine, and bottom hardwoods. The following tabulation gives the areas and the total and per-acre volumes (lumber tally) for each forest condition:

Forest condition	Area	Total volume		Volume per acre	
		Pine	Hardwood	Pine	Hardwood
	Acres	Board feet 1/			
Old-growth pine	5,000	90,000,000	1,500,000	18,000	300
Second-growth pine	70,000	217,000,000	24,500,000	3,100	350
Old-field pine	18,000	36,000,000	-	2,000	-
Bottom hardwoods	7,000	-	23,800,000	-	3,400
Totals, or averages	100,000	343,000,000	49,800,000	3,430	498

1/ Lumber tally in pine trees at least 10 inches d.b.h. and in hardwoods at least 14 inches d.b.h.

Only a small remnant of the total forest area remains in old-growth stands. These are composed chiefly of virgin pines, many of which should be removed because they are defective and rapidly depreciating in value. They also contain much young timber that has replaced the veterans lost through natural causes.

The second-growth stands range in density of saw-timber growing stock from well-stocked stands with 4,000 - 7,000 board feet (lumber tally) per acre down to cut-over areas with less than 1,000 board feet per acre. They are generally composed of trees of many age-classes, including well-stocked patches of reproduction and samplings as well as saw-timber trees. These irregular stands are well suited to selective-timber management. During the first 10-year cutting cycle, some of the lightest stands will not be cut for sawlogs, and consequently the average volume of the growing stock per acre on the cut-over areas will be considerably above 3,100 board feet, the average volume for all second-growth stands. The average stand per acre of 350 board feet of merchantable hardwoods does not accurately depict the stand, because there is a rather large number of undesirable hardwoods, some left from the original cut, which are unsuitable for sawlogs and therefore not included in the saw-timber volume. There are also some pine trees of saw-timber size that are unsuitable for sawlogs. As a general rule, both these pines and hardwoods should be removed in order to make room for trees of higher quality.

Most of the old-field pine stands are even-aged and composed almost entirely of pine in the upper stories, but hardwoods are coming into the lower stories. Stands range in age from those composed largely of saw-timber trees to stands of saplings, but the most prevalent age-class is the pole stand which will grow into saw-timber during the next 10 years. The quality of old-field trees is generally not as high as that of trees in natural second-growth stands. Also there are many limby individuals that will never grow into high-quality saw-timber trees; these should be removed at an early date for pulpwood.

The bottom hardwoods are composed of stands ranging from those recently cut-over (which now bear trees below merchantable size, defective individuals, and unmerchantable species with practically no merchantable saw-timber trees remaining) up to those from which only a few of the largest and best trees were cut many years ago and which now contain some hardwood timber of a very high quality. Most of the stands are unevenaged. Selective-timber management has been tried very little in the hardwoods, but where markets exist for the poor species and low-quality trees it should prove very effective.

A growth study of the property gave the following net growth figures for the different forest conditions after deducting for natural mortality:

Forest condition	Area	Net annual growth per acre		Total annual growth	
		Pine	Hardwood	Pine	Hardwood
	Acres	- - - - - - - -		Board feet 1/ - - - - - - - - -	
Old-growth pine	5,000	250	10	1,250,000	50,000
Second-growth pine	70,000	186	15	13,020,000	1,050,000
Old-field pine	18,000	300	-	5,400,000	-
Bottom hardwoods	7,000	-	200	-	1,400,000
Totals	100,000	197	25	19,670,000	2,500,000

1/ Lumber tally in pines at least 10 inches d.b.h. and in hardwoods at least 14 inches d.b.h.

The net growth in board feet per acre in old-growth stands will be increased considerably by cutting the defective old trees, thus reducing natural mortality and giving more space to the vigorous healthy individuals. Likewise, by selecting for cutting the poorer trees and limiting the cut to less than the growth, the saw-timber growing stock in second-growth stands will be built up and the increment increased. Proper thinnings, removing the poorer trees and reserving the most thrifty and best trees, will stimulate growth in old-field stands.

Management practices

Selective-timber management with a 10-year cutting cycle has been adopted by a large number of lumber companies on large properties in the shortleaf and loblolly pine type. This method of management, which combines good economics and good silviculture, is selected for this example. Studies made by the Southern Forest Experiment Station have shown that it is practical, since volumes as low as 500 board feet per acre can be removed with trucks at only a slightly higher logging cost than volumes of 2,000 - 4,000 board feet per acre. This method removes the non-earning and low-earning timber in the order of its financial maturity and saves the rapidly-growing higher-earning timber until it approaches financial maturity. In practice, however, it may be necessary to cut trees before they are financially mature in order to supply the mill with sawlogs, but this should not be done if logs can be purchased on the open market. Cost-production studies made by the Southern Station have shown that, when only the more mature and the defective trees are cut selectively, higher grades of lumber and considerably higher returns per M board feet of cut are obtained than when clear-cutting is practiced. Lower costs of logging and milling per M board feet also result. The following values for second-growth pine stumpage (including all timber-growing costs and profit) were obtained from this study:

D.b.h. Inches	Stumpage value Per tree	 Per M bd.ft.
12	$.11	$1.43
15	.65	4.04
18	1.87	8.28
22	5.28	9.91

Under good management in second-growth stands, the periodic cut of saw timber should not exceed that amount which the residual stand will restore by growth during the ensuing 10-year period. Because of understocking in most stands, it is desirable to cut less than the growth in order to build up the growing stock and direct the productive capacity of the soil toward its maximum sustained production of high-quality timber. Studies indicate that second-growth stands should contain at least 10,000 board feet (lumber tally) per acre before the entire amount of the growth is removed at the time of each cut. The second-growth stands on this property, which average only 3,100 board feet of pine per acre, are decidedly understocked. With timber growing at 6 percent compounded—about the present rate of growth of the second-growth pine stands on this property—approximately 44 percent of the volume of the saw timber can be removed without depleting the growing stock, since the residual stand will restore this volume through growth during the ensuing 10 years. In order to build up the growing stock on this property, however, it is proposed to limit the cut to approximately 30 percent of the volume of the saw-timber growing-stock in the second-growth pine and bottom-hardwood stands during the first two 10-year periods, and to increase this to 33-1/3 percent in the third period. In the old-field stands, no cut of saw timber is contemplated during the first 10 years, but cuts during the following periods will be about the same as in the second-growth pine stands. In the old-growth, however, a much heavier cut is desirable in order to remove the decadent trees and give more growing space to the reserved, thrifty trees. In order to facilitate regulation of the cutting, a large property of 100,000 acres would be divided into 2 or more large blocks and each block into smaller permanent management units.

This tract, which has had no previous management, is in need of an immediate improvement cutting. Trees that are defective and of poor form or low vigor should be removed, the young growth should be thinned, and hardwoods of inferior species should be removed. As a result of the building of many new pulpmills in the South, there is a widespread market for pulpwood, and a stumpage price of about 75¢ a cord can be obtained at the present time. In many cases the low-quality hardwoods can be disposed of for fuel wood, railroad ties, chemical wood, or fence posts at a small price for stumpage. Cost-production studies of hardwoods removed in improvement cuttings for chemical wood showed a margin for stumpage above all costs of production and marking of about 25¢ a cord. Thinnings and improvement cuttings are desirable in building up the volume, and especially the quality, of saw-timber growing stock, if they can be made without loss. Where markets for pulpwood and fuel wood do not make these operations profitable, stand improvement must proceed more slowly. Improvement cuttings for pulpwood and other inferior products can be made to best advantage in conjunction with the cutting of sawlogs, since the tops of saw-timber trees are commonly utilized for pulpwood, fuel wood, or other low-grade products, along with the trees removed in the improvement cuttings. Studies have shown that for each 1,000 board feet of logs cut in second-growth pine timber, 0.38 cords of pulpwood can be cut from tops and from the trees seriously injured by logging.

Estimated costs and returns

The primary product of this forest is sawlogs, chiefly pine, and the secondary products are pine pulpwood and hardwood fuel wood, ties, or other products, depending upon available markets.

The primary aim of management is gradually to build up the growing stock in quantity and quality until the maximum sustained production of the forest is obtained along with the greatest net returns. Although a sufficient volume will be cut to maintain a profitable operation, the full amount of growth will be cut only in the old-growth stands, in order that a portion may be reserved and added to the growing stock. It should be realized, however, that the full amount of growth could be cut without reducing the capital value of the property, and that the growth reserved and added to the capital value is a part of the income, even if it is not taken at this time. The cut of sawlogs will be increased gradually during each succeeding 10-year period in all understocked stands until full stocking is achieved, when the total volume of growth will be cut. The quality of the sawlogs and their value per M board feet also will increase gradually under a selection method which shifts growth from trees of poor form and vigor to better ones. In order to improve all stands on the tract by selective cutting, it is planned to cut during each 10-year period in all stands in which commercial operations are profitable; in other words, approximately 10,000 acres will be cut over each year, or the entire 100,000 acres will be cut over in 10 years. This is very feasible with truck logging, but some additional gravel roads must be constructed for wet-weather logging. Carefully planned and efficiently constructed all-weather roads over a period of years are less costly than the main-line railroads and spurs used in past operations.

In the following calculations of yields and growth, the stands for each forest condition at the mid-point of each 10-year period were accepted as the average stands for that period. In the first 10-year period, these were obtained by adding 5 years growth, as determined by the growth study, to the present stands in each forest condition. For the two succeeding 10-year periods, the average stands were obtained by adding 10 years growth to the stands after the preceding periodic cut was made. Compounded growth rates of 6 percent for second-growth and old-field pine, 5 percent for second-growth upland and bottom hardwoods, and 4 percent for the old-growth pine and hardwoods, were used.

Tables 1 and 2 present data that summarize the results of management through the next 30 years. All figures have been computed on a per-acre basis. The per-unit values of stumpage for the three periods are given in tables 3, 4, and 5.

Table 1.- Estimated volumes of saw timber[1], and cuts and growth per average acre by forest conditions for three 10-year periods

Item	Beginning 1st 10-year period		Mid-point 1st 10-year period		Mid-point 2nd 10-year period		Mid-point 3rd 10-year period		End of 3rd 10-year period	
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	- - - - - - - - - - - - Board feet (lumber tally) - - - - - - - - - - - -									
d-growth pine										
and before cut	18,000	300	19,250	350	14,800	296	14,800	296	12,170	243
and after cut	-	-	10,000	200	10,000	200	10,000	200	-	-
lume cut	-	-	9,250	150	4,800	96	4,800	96	-	-
owth added to rowing stock	-	-	-	-	-	-	-	-	-	-
tal growth ince last cut	-	-	[2]1,250	[2]50	4,800	96	4,800	96	[2]2,170	[2]43
erage annual rowth	-	-	250	10	480	10	480	10	434	9
cond-growth pine										
and before cut	3,100	350	4,030	425	5,068	489	6,390	552	5,700	468
and after cut	-	-	2,830	300	3,568	339	4,260	367	-	-
lume cut	-	-	1,200	125	1,500	150	2,130	185	-	-
owth added to rowing stock	-	-	-	-	738	39	692	28	-	-
tal growth ince last cut	-	-	[2]930	[2]75	2,238	189	2,822	213	[2]1,440	[2]101
erage annual rowth	-	-	186	15	224	19	282	21	288	20
d-field pine										
and before cut	2,000	-	3,500	-	6,268	-	7,644	-	6,883	-
and after cut	-	-	3,500	-	4,268	-	5,144	-	-	-
lume cut	-	-	-	-	2,000	-	2,500	-	-	-
owth added to rowing stock	-	-	1,500	-	768	-	876	-	-	-
tal growth ince last cut	-	-	[2]1,500	-	2,768	-	3,376	-	[2]1,739	
erage annual rowth	-	-	300	-	277	-	338	-	348	-
ttom hardwoods										
and before cut	-	3,400	-	4,400	-	5,050	-	5,783	-	4,82
and after cut	-	-	-	3,100	-	3,550	-	3,783	-	-
lume cut	-	-	-	1,300	-	1,500	-	2,000	-	-
owth added to rowing stock	-	-	-	-	-	450	-	233	-	-
tal growth ince last cut	-	-	-	[2]1,000	-	1,950	-	2,233	-	[2]1,04
erage annual rowth	-	-	-	200	-	195	-	223	-	20

Pine trees 10 inches d.b.h. and larger and hardwoods 14 inches d.b.h. and larger.
Total volume of growth during 5 years.

Table 2. - Estimated value of saw-timber[1] cuts and growth per average acre by forest conditions for three 10-year periods

Item	Mid-point 1st 10-year period		Mid-point 2nd 10-year period		Mid-point 3rd 10-year period		End of 3rd 10-year period	
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	Dollars							
Old-growth pine								
Volume cut	69.37	1.12	40.80	.82	40.80	.82	-	-
Growth added to growing stock	-	-	-	-	-	-	-	-
Total growth since last cut	[2]9.37	[2].37	40.80	.82	40.80	.82	[2]18.44	[2].37
Average annual growth	1.87	.07	4.08	.08	4.08	.08	3.69	.07
Second-growth pine								
Volume cut	6.00	.62	9.00	.90	14.91	1.29	-	-
Growth added to growing stock	-	-	4.43	.23	4.84	.20	-	-
Total growth since last cut	[2]4.65	[2].37	13.43	1.13	19.75	1.49	[2]10.08	[2].71
Average annual growth	.93	.07	1.34	.11	1.97	.15	2.02	.14
Old-field pine								
Volume cut	-	-	8.00	-	12.50	-	-	-
Growth added to growing stock	6.00	-	3.07	-	4.38	-	-	-
Total growth since last cut	[2]6.00	-	11.07	-	16.88	-	[2]8.70	-
Average annual growth	1.20	-	1.11	-	1.69	-	1.74	-
Bottom-hardwoods								
Volume cut	-	6.50	-	9.00	-	14.00	-	-
Growth added to growing stock	-	-	-	2.70	-	1.63	-	
Total growth since last cut	-	[2]5.00	-	11.70	-	15.63	-	[2]7.31
Average annual growth	-	1.00	-	1.17	-	1.56	-	1.46

[1] Pine trees 10 inches d.b.h. and larger and hardwoods 14 inches d.b.h. and larger.
[2] Total value of growth for 5 years.

Table 3 shows the volumes of yields and gross returns from pine and hardwood stumpage cut as saw timber, pulpwood, and fuel wood during the first 10-year period. The stumpage values used for saw timber are somewhat higher than present current stumpage prices, but these values have been obtained on U. S. Forest Service sales and can be obtained by efficient managers for stumpage produced under good forest management. Cost-production studies made by the Southern Forest Experiment Station in similar timber, and of pulpwood and fuel wood production, have shown that the stumpage prices for these products are reasonable. Although pulpwood markets have greatly expanded over the South during the past 2 years, some owners do not yet have a market for pulpwood. In many more localities, moreover, there is not a ready market for hardwood fuel wood on a large scale, but the future market for low-quality hardwoods appears to be more favorable. If such markets do not exist, of course, the forest owner has only his income from saw timber.

Table 4 shows for the second 10-year period the volumes and gross values of stumpage cut as saw timber, pulpwood, and fuel wood. Stumpage values of saw timber have been increased over those of the first 10-year period because the quality of logs cut will be considerably higher than that of logs cut during the first 10-year period and not because of any increase in the general market prices of stumpage. The cut of sawlogs is also heavier for the property as a whole, because the volumes of growing stock and of increment are considerably greater than they were during the previous period.

Table 5 shows volumes and gross values of stumpage cut during the third 10-year period.

It should be observed that only the values of timber cut have been included in these gross yields and returns; although the gross yields and incomes represented by the growth reserved from cutting(and added to the growing stock) might well be included, they have not been.

A comparison of tables 3 and 5 shows that the cut of saw timber increased from 148,850 M board feet during the first 10-year period to 245,530 M board feet during the third 10-year period, while the gross values of saw-timber stumpage increased from $861,750 to $1,665,430. The total gross income from all products increased from $104,650 per year, or $1.046 per acre per year, for the first period to $179,255.50 per year, or $1.793 per acre per year, for the third period.

For a large property, the costs of forest management include taxes, fire protection, inventory, marking of timber for cutting, and supervision of the cutting. Most owners of large forest properties do not consider interest on the money invested in the property as a cost unless actually paid out on borrowed money, and so interest is not included in this paper. In the case of operating lumber companies the costs of supervision of cutting and, in many cases, the marking of timber are considered as costs of logging, but in this paper, which is limited to timber management, they are considered as costs of growing stumpage.

Taxes vary from state to state and also from county to county within states. An annual tax of 12¢ per acre has been accepted as representative for large properties in this forest region. With the building up of the growing stock and the resulting increased gross income, taxes on the property may be increased. The present tendency in the South, however, is to lower

Table 3.- Yields and gross returns - first 10-year period

Products by timber classes	Area	Yield per acre		Total yield			Gross returns	
		Pine	Hardwood	Pine	Hardwood	Total	Per unit	Total
	Acres	Board feet		- - - - M Board feet - - - -			- - - - Dollars - - - -	
Saw timber[1]								
Old-growth	5,000	9,250	150	46,250	750	47,000	7.50	352,500
Second-growth	70,000	1,200	125	84,000	8,750	92,750	5.00	463,750
Bottom hardwoods	7,000	-	1,300	-	9,100	9,100	5.00	45,500
Total saw timber				130,250	18,600	148,850		861,750
Pine pulpwood[2]								
		Cords		Cords				
Second-growth	70,000	1½		105,000			.75	78,750
Old-field	18,000	5		90,000			.75	67,500
Total				195,000				146,250
Hardwood fuel wood[2]								
					Cords			
Second-growth	70,000		2		140,000		.25	35,000
Bottom hardwoods	7,000		2		14,000		.25	3,500
Total					154,000			38,500
Total gross returns first 10-year period								1,046,500.00
Total gross returns per year								104,650.00
Total gross returns per acre per year								1.046

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[1] Pine trees 10 inches d.b.h. and larger and hardwoods 14 inches d.b.h. and larger. Volumes are in board feet lumber tally.

[2] Cut from trees removed in improvement cuttings and thinnings and from tops of trees felled in logging. Volumes are in standard cords (4 x 4 x 8 ft.).

Table 4.- Yields and gross returns - second 10-year period

Products by timber classes	Area	Yield per acre		Total yield			Gross returns	
		Pine	Hardwood	Pine	Hardwood	Total	Per unit	Total
	Acres	Board feet		- - -	M Board feet	- - - -	- - - -Dollars	- - - -
Saw timber[1]								
Old-growth	5,000	4,800	96	24,000	480	24,480	8.50	208,080
Second-growth	70,000	1,500	150	105,000	10,500	115,500	6.00	693,000
Old-field	18,000	2,000	-	36,000	-	36,000	4.00	144,000
Bottom hardwoods	7,000	-	1,500	-	10,500	10,500	6.00	63,000
Total saw timber				165,000	21,480	186,480		1,108,080
Pine pulpwood[2]								
		Cords		Cords				
Second-growth	70,000	1		70,000			.75	52,500
Old-field	18,000	1½		27,000			.75	20,250
Total				97,000				72,750
Hardwood fuel wood[2]								
					Cords			
Second-growth	70,000	1			70,000		.25	17,500
Bottom hardwoods	7,000	2			14,000		.25	3,500
Total					84,000			21,000
Total gross returns **second 10-year period**								1,201,830.00
Total gross returns per year								120,183.00
Total gross returns per acre per year								1.202

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[1] Pine trees 10 inches d.b.h. and larger and hardwoods 14 inches d.b.h. and larger. Volumes are in board feet lumber tally.

[2] Cut from trees removed in improvement cuttings and thinnings and from tops of trees felled in logging. Volumes are in standard cords (4 x 4 x 8 ft.).

Table 5.- Yields and gross returns - third 10-year period

Products by timber classes	Area	Yield per acre		Total yield			Gross returns	
		Pine	Hardwood	Pine	Hardwood	Total	Per unit	Total
	Acres	Board feet		M Board feet			Dollars	
Saw timber[1]								
Old-growth	5,000	4,800	96	24,000	480	24,480	8.50	208,080
Second-growth	70,000	2,130	185	149,100	12,950	162,050	7.00	1,134,350
Old-field	18,000	2,500	-	45,000	-	45,000	5.00	225,000
Bottom hardwoods	7,000	-	2,000	-	14,000	14,000	7.00	98,000
Total saw timber				218,100	27,430	245,530		1,665,430
Pine pulpwood[2]								
		Cords		Cords				
Old-growth	5,000	1		5,000			.75	3,750
Second-growth	70,000	1½		105,000			.75	78,750
Old-field	18,000	1 3/4		31,500			.75	23,625
Total				141,500				106,125
Hardwood fuel wood[2]								
					Cords			
Second-growth	70,000		1		70,000		.25	17,500
Bottom hardwoods	7,000		2		14,000		.25	3,500
Total					84,000			21,000
Total gross returns third 10-year period								1,792,555.00
Total gross returns per year								179,255.50
Total gross returns per acre per year								1.793

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[1] Pine trees 10 inches d.b.h. and larger and hardwoods 14 inches d.b.h. and larger. Volumes are in board feet lumber tally.

[2] Cut from trees removed in improvement cuttings and thinnings and from tops of trees felled in logging. Volumes are in standard cords (4 x 4 x 8 ft.).

rather than to raise taxes on forest properties. In this example, taxes have been set at 15¢ per acre per year during the second 10-year period and at 20¢ during the third period.

Fire protection is furnished to forest owners in the shortleaf and loblolly pine type in most Southern States for about 2¢ per acre per year by the states cooperating under the Clarke-McNary Act. A cost of 3¢ has been used, however, so that some additional fire-suppression work may be provided.

Studies of costs of marking and at the same time making 100-percent cruises of second-growth saw timber show that costs amount to about 10¢ per M board feet cut. Marking pulpwood and chemical wood costs about 3½¢ per cord. It is estimated that 20¢ per M board feet and 7¢ per cord will cover adequately all costs of cruising, marking, and supervising of cutting.

Table 6 gives the costs, excluding interest on the investment, of managing the whole property for each of the three 10-year periods.

The net returns, including stumpage, interest, and profit, for the whole property during the first 10-year period is the gross income of $1,046,500 minus the total expenses of $204,200, or $842,300. On an annual per-acre basis, this is $.842. For the second 10-year period the net income has increased to $971,864 for the property as a whole, or $.972 per acre per year; and for the third 10-year period, to $1,497,664 for the property as a whole, or $1.498 per acre per year. For the 30-year period the net income amounts to $3,311,828, or $1.104 per acre per year. Here, as in computing gross incomes, the values of growth added to the growing stock have not been considered in computing net incomes.

The following table gives the estimated value of this property based on current market values of land and stumpage. It should be pointed out, however, that companies owning valuable properties, are not offering them for sale, but rather are practicing continuous forest management. Good properties, nevertheless, can often be blocked up by purchasing a number of smaller properties.

100,000 acres of land, exclusive of timber, at $3.00 per acre	$300,000
91,500 M bd. ft. of virgin timber at $5.00 per M bd. ft.	457,500
301,300 M bd. ft. of second-growth timber at $3.00 per M bd. ft.	903,900
Total value	$1,661,400
Average value per acre	$16.61

It will be noted that the current market values of stumpage used in the above table are less than those applied to the stumpage cut during the first 10-year period. This is quite logical, since it is to be expected that purchasers of tracts of forest land will drive some sharp bargains and, furthermore, they cannot be expected to pay the same price for stumpage to be held for some years before cutting as would an operator who is purchasing stumpage that will be cut immediately. The quality of stumpage, which on a purchased area includes all pines of saw-timber quality 10 inches d.b.h. and larger and all hardwoods 14 inches d.b.h. and larger, is much lower than that of stumpage in trees marked for cutting during the first 10-year period.

Table 6.- Costs of management

	Dollars
1st 10 years	
Taxes at 12¢ per acre per year (100,000 acres)	120,000.00
Fire protection at 3¢ per acre per year (100,000 acres)	30,000.00
Marking, estimating, supervision for sawlog cutting at 20¢ per M bd. ft. (148,850 M bd.ft.)	29,770.00
Marking and supervision for cutting pulpwood at 7¢ per cord (195,000 cords)	13,650.00
Marking and supervision for cutting hardwood fuel wood at 7¢ per cord (154,000 cords)	10,780.00
Total cost 10 years	204,200.00
Total cost per year	20,420.00
Total cost per acre per year	.204
2nd 10 years	
Taxes at 15¢ per acre per year (100,000 acres)	150,000.00
Fire protection at 3¢ per acre per year (100,000 acres)	30,000.00
Marking and supervision for sawlog cutting at 20¢ per M bd.ft. (186,480 M bd.ft.)	37,296.00
Marking and supervision for cutting pulpwood at 7¢ per cord (97,000 cords)	6,790.00
Marking and supervision for cutting hardwood fuel wood at 7¢ per cord (84,000 cords)	5,880.00
Total cost 10 years	229,966.00
Total cost per year	22,996.60
Total cost per acre per year	.230
3rd 10 years	
Taxes at 20¢ per acre per year (100,000 acres)	200,000.00
Fire protection at 3¢ per acre per year (100,000 acres)	30,000.00
Marking and supervision for sawlog cutting at 20¢ per M bd. ft. (245,530 M bd.ft.)	49,106.00
Marking and supervision for cutting pulpwood at 7¢ per cord (141,500 cords)	9,905.00
Marking and supervision for cutting hardwood fuel wood at 7¢ per cord (84,000 cords)	5,880.00
Total cost 10 years	294,891.00
Total cost per year	29,489.10
Total cost per acre per year	.295

The net incomes per acre per year for the three 10-year periods earn the following rates of interest annually on an investment value of $16.61 per acre:

10-year period	Net income per acre per year	Rate of interest earned on investment of $16.61 per acre
First	$.842	5.1
Second	.972	5.8
Third	1.498	9.0
Average	$1.104	6.6

If the additions to the growing-stock investment from saving growth are taken into consideration, however, these percents would be reduced in the second and third periods.

Attention has been called in several placed to the fact that the three cuts did not remove all of the growth made during each period. A part was reserved and added to the growing stock, thus increasing the volume and improving the quality of timber. The total volume of saw timber at the beginning of the first 10-year period was 343,000 M board feet of pine and 49,800 M board feet of hardwoods, and after 30 years, i.e., at the end of the third 10-year period, it is estimated as 583,744 M board feet of pine and 67,764 M board feet of hardwoods; this is a gain of 240,744 M board feet (70 percent) of pine and 17,964 M board feet (36 percent) of hardwoods. The net growth of both pine and hardwoods, which is added to the growing stock, amounts to 258,708 M board feet, which at $6.00 per M board feet has a gross value of $1,552,248. On an annual per-acre basis this amounts to an average of 86.2 board feet, or $.517, during the 30-year period. If this is added to the average net income of $1.104 per acre per year, received from the timber cut, the total becomes $1.621 per acre per year for the 30-year period. The following tabulation gives total and per-acre volumes by stand conditions at the end of 30 years:

Forest condition	Area	Total volume		Volume per acre	
		Pine	Hardwood	Pine	Hardwood
	Acres	Board feet 1/			
Old-growth pine	5,000	60,850,000	1,215,000	12,170	243
Second-growth pine	70,000	399,000,000	32,760,000	5,700	468
Old-field pine	18,000	123,894,000	-	6,883	-
Bottom hardwoods	7,000	-	33,789,000	-	4,827
	100,000	583,744,000	67,764,000	5,837	678

1/ Lumber tally in pine trees 10 inches d.b.h. and larger and in hardwoods 14 inches d.b.h. and larger.

Based on the calculations in this paper, therefore, sustained-yield management of large properties of shortleaf and loblolly pine is profitable. In fact, selective-timber management is currently more profitable than clear-cutting, because in the latter (1) many small immature trees are cut which yield little net income and may result in a loss; (2) depletion charges must be added to costs; (3) the depreciation costs are increased; and (4) the business must be concluded and new investments sought. Selective-timber management, on the other hand, is good business from the start. It gradually builds up the growing stock and at the same time yields progressively increasing net returns, which compare favorably with those from other sound investments.

Note: The Southern Forest Experiment Station hereby wishes to acknowledge the clerical assistance received from the Works Progress Administration in the preparation of this Paper.

OCCASIONAL PAPER NO. 80 FEBRUARY 18, 1939

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THE EXTENT OF LONG-TERM TAX DELINQUENCY IN CERTAIN OKLAHOMA COUNTIES

by

Ronald B. Craig, Associate Forest Economist,
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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Note: Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Projects 701-3-9 and 365-64-3-7.

THE EXTENT OF LONG-TERM TAX DELINQUENCY IN CERTAIN OKLAHOMA COUNTIES

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INTRODUCTION

Purpose of study

Contrary to the requirements of the Fulmer Act (Public No. 395 - 74th Congress)[1], tax-forfeited lands under present Oklahoma law pass to the county, and no provision is made for blocking such lands into State forests. Hence this State will not be eligible for participation in Fulmer Act funds after 1942, nor can it be given preference in the grant of such funds prior to 1942.[2] In view of this situation, the Division of Forestry of the Oklahoma Planning and Resources Board requested the assistance of the United States Forest Service in drafting suggestions for amending the present State code in order to bring it into line with the requirements set forth in the Federal Act. Since such amendment would necessitate certain major alterations in the present administrative procedure in respect to tax-delinquent lands, it was believed both by the Oklahoma Planning and Resources Board and by the Forest Service that the proposed changes could be explained and justified more readily by presenting to the Legislature, Planning Board, and other interested agencies, current factual data on the extent, location, and tax history of chronically tax-delinquent lands in certain representative counties of the State. Also since the problem of chronic tax delinquency is State-wide, and since there are probably more acres of submarginal grazing land than of submarginal forest land in the State, it was evident that the problem of disposing of chronically delinquent forest land could not be solved apart from the consideration of the treatment of delinquent land of all types. Hence studies were made during 1938 in counties in all parts of the State except the central prairies (fig. 1); in this region delinquency is at a minimum.

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[1] Briefly, the Act authorizes the Federal government to acquire, by purchase or otherwise, tax-forfeited or other lands suitable for public forests and to turn back the said lands to the State in which they lie for use as State forests, the State to reimburse the Federal government out of the proceeds derived from use and development of the areas. Section 2(a) of the Act provides, among other requirements, that no State shall be eligible after June 30, 1942, for participation in the Federal grants authorized in this Act unless it has, by that date, provisions in its statutes: (1) for vesting tax title in fee in the State or a political unit thereof, and (2) for "blocking into State....forests the areas which are more suitable for public than for private ownership, and which, in the public interest, should be devoted primarily to the production of timber crops and/or the maintenance of forests for watershed protection."

[2] Congress has not yet implemented the Fulmer Act by an appropriation setting up the special fund authorized in the Act.

Scope of study

The counties in which complete data were obtained were: (1) Adair, in the upland hardwood region of the Ozark Plateau; (2) Beaver, in the grazing region of the Panhandle; (3) Creek, in the Eastern Cross Timbers; (4) Jackson, in the Rolling Prairie of the southwestern grazing area; (5) Latimer, in the shortleaf pine-hardwood region of the Kiamichi Plateau; and (6) Love, in the Southern Cross Timbers of the Red River Valley. Partial data were obtained in Carter County, just north of Love, and in Tillman County, southeast of Jackson.

In the first six counties, data were obtained from the tax rolls and "Sale records"[3/] on the location, area, assessed value, and delinquency history (a) of each tract that was already owned in fee by the county through purchase at resale, and (b) of each tract that was eligible for resale for delinquent taxes. These tracts, together with Federally- and State-owned lands, were platted on township plats. Data were also obtained on the trends in assessed value of all property in the county (realty, personalty, and corporation property) for the period covered by the study of delinquency—for the past decade, if data were available.

In Carter and Tillman Counties only partial data (based on average delinquency of each county as a whole) were obtained, since the time and funds available did not permit a more detailed study.

LAW AND PRACTICE IN RESPECT TO TAX DELINQUENCY

Summary of laws governing tax-delinquency procedure

Rural real estate is assessed by the county assessor,[4/] theoretically at 100 percent of full value, as of Jan. 1. Taxes, which are levied by the county,[5/] become due in November of the assessing year for the first (half) installment and in April of the following year for the second installment. First installments on taxes become delinquent (i.e., subject to 12 percent penalty) in January of the year following assessment (or 60 days after tax rolls are filed with the county treasurer), and the second installment becomes delinquent on June 15, if the first installment has been paid. If the taxes are not paid before the first Monday of November of the year following assessment, the property is subject to "sale" (hereinafter referred to as the "tax sale"), the county treasurer issuing a tax certificate. Lands not bid in by private purchasers (who must bid at least the total amount of taxes, penalty, and costs due and accrued) are "bid in" by the county. The tax certificate is merely a lien against the property, and does not convey the right of use or possession. If the land is not redeemed by the original owner (or by those claiming under or through him) by April of the third year following the original tax sale, the land is subject to "resale" (so referred to hereafter in this report). If no private person will bid the total amount of taxes, penalties, and costs due, the land may be "bought in" by the county,

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[3/] The county's list of lands "bid in" by the county at each annual (or periodic) tax sale, showing description, area, amount of taxes due, and status as to redemption. See next section of this report for discussion of law and procedure.

[4/] Public utilities are assessed by the State Tax Commissioner.

[5/] Okalahoma levies no State tax on property.

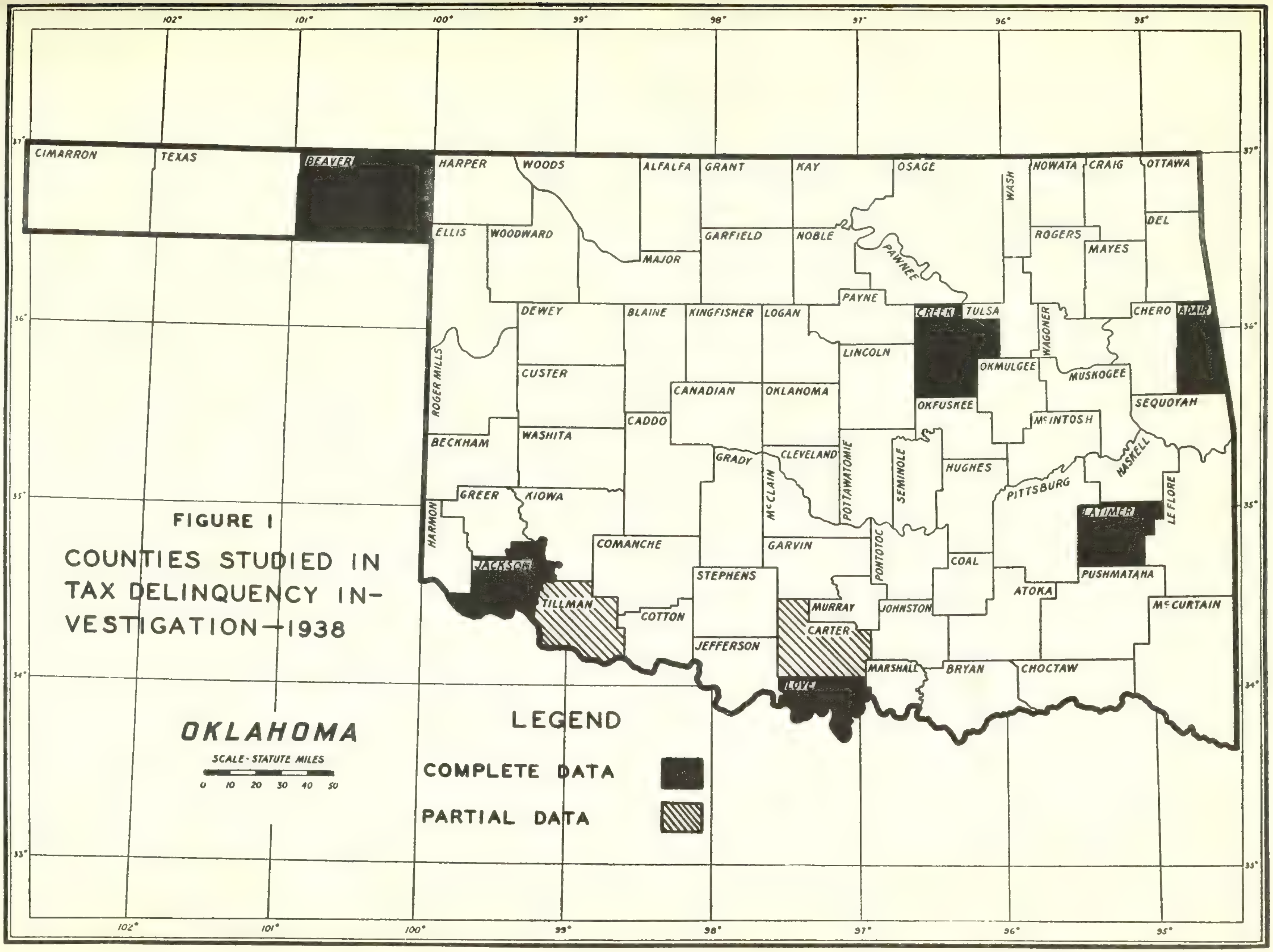

FIGURE I

COUNTIES STUDIED IN TAX DELINQUENCY INVESTIGATION—1938 and a deed issued by the county treasurer to the county commissioners. During the year following resale, however, such deed (or one issued to a private purchaser) is subject to attack on the grounds of technical defects in prior procedure, at the end of which period the deed is free from such attack, saving only for minors, insane, and other incompetent persons. The statutes also provide that both the tax sale and the resale "shall" be held annually, but the county officials disregard this provision with impunity.[6] Indeed, in only one of the eight counties studied had a resale been held since 1931, and in one county no "annual" tax sale had been held since 1930.

Local variations in tax-delinquency procedure

The failure to hold annual tax sales and resales, coupled with the extreme complexity of the lengthy statutes governing tax-delinquency procedure, homestead exemption, State school-land loans and leases, and similar fiscal and administrative procedures, has led to wide variations among the 77 counties of Oklahoma in methods of tax-collection enforcement. Indeed, two completely opposite systems of handling continued delinquency are in use, both with some apparent legal sanction.

Under the first (and most common) system, taxes subsequently becoming delinquent are endorsed on the original tax certificate, together with penalty and costs. At resale, this certificate, with the grand total of all taxes and other charges shown, is offered for sale, and the purchaser must pay the total amount to acquire it. He then knows that he has satisfied all outstanding county claims against his title, and that, if no action on grounds of technical procedural defects is brought within 1 year after resale, he will have a sound title. Likewise, if the county buys the same certificate, it can convey a good title by a Commissioners' deed, or it can hold and use the land under a title in fee. Under this system, however, assuming (as has been the case in recent years) that resales are held at intervals of 3 to 6 years rather than annually, an original owner wishing to redeem his property must also pay the full amount of taxes, penalties, and costs due and accrued from the time of original delinquency up through the year of redemption. When an outstanding tax certificate has had subsequent delinquent taxes, penalties, and costs endorsed upon it for 3 or 4 years, this frequently tends to discourage or even prevent redemption, particularly if the property is overassessed or is located in a district subject to a millage rate disproportionately high in comparison with some other districts. Nevertheless, a study of the statutes leads to the belief that this method, while not specifically required, conforms more nearly to the legislative intent than the following method.

This second method avoids endorsement of subsequent delinquent taxes by "selling" the land at each annual tax sale for the delinquent taxes currently due, and issuing a tax certificate covering the unpaid taxes of that year. In this way, as many as five or six certificates may be outstanding in the hands of as many different purchasers, each for a given year, on the same piece of property. Obviously, any one of these certificates may be redeemed at any time prior to resale, when a prospective purchaser, in order to insure obtaining a sound title, has to purchase each and every certificate outstanding against the property, irrespective of the year of issue. This may involve a detailed and sometimes worthless search of the county records, since it is clearly evident that the local records of the counties that use this second method do not lend themselves to a simple and accurate determination of the tax status of a particular property. Advocates of this method claim, probably justly, that it facilitates restoration of delinquent properties to the tax roll. This is true chiefly, however, because resales are not held annually, thereby making it possible for the owner to redeem successive annual tax certificates and thereby to stave off eligibility of his property for resale until he can redeem all certificates, or decides to give up the struggle and let his property sell at resale. It would appear that in normal times, or even in short periods of depression, the present redemption period (actually $2\frac{1}{2}$ years from tax sale, plus another year to attack a tax title on procedural grounds) affords adequate protection to the taxpayer against hasty or unjust foreclosure of tax liens.

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[6] The citations for this summary of the tax laws are as follows: Art. 25, ss. 12705-12713, Chap. 66, Okla. Code 1931, as amended by Chap. 104, Acts of 1933; and Art. 28, ss. 12719-12778, Chap. 66, Okla. Code 1931, as amended by Acts of 1933 and 1935.

One other item in connection with these two methods of recording delinquency requires mention at this point. While the statutes state (Art. 28, Chap. 66, 1931 Code) that no taxes are to be extended on the tax roll on delinquent property "sold" to the county at the tax sale (or, of course, on that bought by the county at resale),[7] no mention is made of extending the assessed values of such properties. It is the general practice in Oklahoma (though not in any other State of the South) to continue to assess such properties biennially[8] and to extend the value on each year's assessment and tax roll until such time as that particular property is sold at resale to the county.[9] This practice is followed irrespective of the method of handling subsequently delinquent taxes (i.e., "endorsement" or "annual tax sale" method). Its major effect, of course, is to build up a fictitious value base in a county, against which warrants or bonds can be issued, even though no tax revenue is derived from the delinquent portion of that base. Obviously, the greater the extent of delinquency in a county the larger the fictitious portion of the value base becomes, while the possibilities for ultimate financial collapse increase. To offset this tendency, some county assessors (generally instigated by the county treasurer) make sharp reductions in the assessed values of delinquent properties at the first assessment subsequent to the tax sale at which these properties were bid in by the county, and continue to hold these values at these reduced figures until resale solves the problem one way or the other. Study of the statutes, however, leads to an opinion on the part of the writer, confirmed by an unofficial opinion of an Assistant Attorney-General of the State, that such extension of assessments is not only non-mandatory but also not even within the legislative intent. Why it has been allowed to continue ever since the first tax sale of 1909, however, is not apparent.

It has been stated previously that the statute requiring annual resales is disregarded openly. The claim is made by county officials that the high cost of holding a legal resale (chiefly, the costs of preparing the list of lands, with their areas and the taxes, penalties, and costs due, and of advertising the same once a week for 4 weeks) results in a net loss to the county treasury, since the revenue from the relatively few sales of land to private purchasers does not cover the total costs of sale over and above the amount of delinquent taxes due. Inasmuch, however, as no county (so far as the writer could ascertain) has attempted in recent years to hold annual resales, it is quite likely that this opinion is based on the costs of the resales (triennial up to septennial) with which the county officials are now familiar.[10]

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[7] Taxes are computed, however, and endorsed on the tax certificate, for each year for which they are delinquent; or, in counties using the second method just described, are computed and, if unpaid, are entered on the certificate, which is then offered for sale at the "annual" tax sale.

[8] Rural real estate is assessed biennially, rather than annually.

[9] If sold to a private person, the property is restored to the tax roll as soon as a deed is issued, when it becomes subject to taxation.

The preparation and advertising of such lengthy lists, with the exhaustive check of the records required, is undoubtedly expensive. Furthermore, irrespective of whether there be outstanding but one tax certificate with endorsed taxes for several years, or four or five annual certificates, the accumulated taxes, penalties, and costs are increasingly greater the longer the period between tax sale and resale. This in turn tends to "raise the price" of the property above what it would be if there were due only the taxes, penalties, and costs (including taxes of current year) for the 3 years since the original delinquency. This latter factor may account in large measure for the failure of private purchasers to bid for otherwise desirable properties, particularly in those counties where chronic delinquency is greatest and where, in general, assessments or rates are higher than in counties suffering less from nonpayment of taxes. Where chronic delinquency is the result of the submarginal character of the land, or the removal or deterioration of a major resource, these criteria probably do not apply.

LONG-TERM DELINQUENCY IN SAMPLE COUNTIES — EXTENT AND TRENDS

General considerations

Inasmuch as this study was made in the summer of 1938, only those tracts which were eligible for resale in 1938 (or, in two counties—Creek and Love—which would be eligible in April 1939) and those which had already been bought in by the counties at prior resales were included in the study. Stated another way, those tracts delinquent for the taxes of 1934 and "bid in" by the county in November 1935 (in two counties, those delinquent for 1935 taxes and "bid in" in 1936) were the most recently delinquent tracts to be studied. All delinquencies for years prior to 1934, back to the year in which the most recent resale was held (generally 1931), were also included, together with all properties which had forfeited to the counties at any resale since Oklahoma acquired statehood (1907) and which were, as of 1938, still in county title.

The relative extent of long-term delinquency among the counties can be measured neither by the area in county title nor by the delinquent area derived from any tax sale, since irregularities and coincidences of resales and tax sales among the counties govern the actual tax status, e.g., as between land forfeited to county title and merely delinquent for 1934 taxes.

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[10] In this connection, however, see: Allen, H. K. Forfeiture of real property rights through tax delinquency. Jour. Land and Public Utility Economics 14 (4): 382-387. Nov. 1938.

Hence the clearest comparison among counties in respect to over-all delinquency is the "total area involved in long-term delinquency." As used in this report, this area includes: (1) all land forfeited to, and now in, county title for nonpayment of taxes; (2) all land eligible for resale as of 1938 (1939 in two counties); and (3) all land which would have been eligible for resale save for technical errors in advertising the same.

Latimer County

Latimer County lies in the shortleaf pine-hardwood region, near the northwestern edge of the Kiamichi Plateau, in southeast Oklahoma (fig. 1). A small isolated area of the Eastern Prairies lies on the west-central border of the county. The topography is characterized by the wide valley of Fourche Maline, running east and west through the center of the county, and by the successive high ridges of the Kiamichi Mountains to the south and of the Sanbois Mountains to the north. Elevations above sea level range from less than 700 feet, where Fourche Maline crosses the eastern boundary, to about 1,850 feet, on the crest of Buffalo Mountain near the southern boundary. The southern half of the county is somewhat isolated by the parallel ranges of hills and by lack of all-weather roads. A Federal highway and a through line of the Chicago, Rock Island, and Pacific Railroad traverse the Fourche Maline valley, in which the towns of Red Oak, Wilburton (county seat), and Gowen are located.

The gross area of the county is 470,400 acres, and its 1930 population was 11,184 persons, or 15 per square mile. Approximately 80 percent of the county is forest land, the chief species being shortleaf pine, hickory, and red, black, and post oaks. All the old-growth timber has been cut out, and even the remaining second growth has been heavily culled for mine timbers and by small portable mills for low-grade lumber. In 1934, only 78,119 acres were in cultivation, while 57,000 acres were in farm woodlands.[11]

An important feature of Latimer County's tax base is that, in 1937, corporation property (chiefly the C.R.I. & P. and M-K-T. Railroads) formed 49 percent of the total base, while all other real estate formed only 43 percent and all other personalty formed 8 percent. Data in table 1 indicate that since 1928 real estate has been declining as a factor in the tax base, while corporation property has been increasing. The total tax base (total assessed value) of the county has declined by 43 percent in this same period (table 1). Part of this decline, however, was caused by a State-wide reduction of 20 percent in all values in 1932, ordered by the State Board of Equalization. Inasmuch as only two resales (1930 and 1936) have been held during this 9-year period, it is evident that the decline in real-estate value is not attributable chiefly to removal from the tax base of the lands bought by the county. The value, as of 1929, of lands sold to the county at the April 1930 resale (and still off the tax roll) accounted for less than 4 percent of the total decline in real-estate value between 1929 and 1935, while the value, as of 1935, of the lands sold to the county in April 1936 accounted for only 25 percent of the decline in real-estate value between 1935 and 1937. The much higher percentage figure for the 1936 resale is attributable: (1) to the much greater delinquent area still unsold from the recent resale, and (2) to the shorter period of reference (2 years rather than 6 years) of the decline in total values. Chief factors in this decline in assessments are, of course, the decline in "true" values during the depression, and the removal of much of the value of two major resources—coal and timber.

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[11] U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

Table 1.- Changes in assessed values, 1928-1937, Latimer County, Oklahoma 1/

Assessment year	Real estate		Personal property		Corporation property		Total	
	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total
	Dollars		Dollars		Dollars		Dollars	
1928	2/	-	2/	-	2,443,674	30	6,165,944	100
1929	3,064,708	-	546,257	-	3/	-	3/	-
1932	4/	-	4/	-	4/	-	4,463,031	100
1935	1,961,403	53	541,982	15	1,230,592	32	3,733,977	100
1937	1,504,748	43	273,233	8	1,725,127	49	3,503,108	100

1/ Data from county assessment rolls unless otherwise indicated.
2/ Data are from Report of State Auditor for fiscal year ending June 30, 1928. The breakdown between real and personal property is not available. Total real and personal value is $3,727,270, or 70 percent of the total tax base.
3/ The county records of assessment of corporation property and of total value are missing.
4/ Only total value is available. Data are from U. S. Bureau of the Census. Realty tax delinquency. Vol. 1. Current tax delinquency by States and counties, Levies of 1932-1933. Washington. 1934.

Latimer County is the only one among the eight studied which has held a resale since 1931. This county has held resales in 1919, 1922, 1924, 1925, 1926, 1930, and 1936. No tax sales were held in 1936 or 1937, and hence no properties would be eligible for resale in 1938 or 1939. Data on currently delinquent properties not yet eligible for resale were not obtained in this study, but in table 2 are presented data on the area and assessed value of rural properties in county title as of May 1938, which were bought by the county at the resales of 1936, 1930, and 1926 or earlier years. Assessed values shown for the 1936 and 1930 resales are as of 1935 and 1929, respectively, but the assessment of the properties acquired in 1926 or earlier years are not available in the county records. The values shown under "Total" are the sum of the 1935 and 1929 values and, of course, are exclusive of the values of the tracts bought in 1926.

Analysis of the data in table 2 indicates a close relationship between topography (as a factor of land use and accessibility) and delinquency. Buffalo and Salonia Townships, which together contain nearly half the forfeited area of the county, are the two most mountainous and isolated townships of the county. On the other hand, Gowen and Cravens Townships, which together contain less than 10 percent of the forfeited area of the county, are the most level, populous, and accessible townships, lying in the Fourche Maline Valley along U. S. Highway 270 and the C.R.I. & P. Railroad.

Table 2.- Area and assessed value of land in county title through purchase at resales, as of May 1938, Latimer County, Oklahoma[1]

Civil townships	Year of resale:						Total		Ratio of township totals to grand totals	
	1936		1930		1926 or prior					
	Area	Value 1935	Area	Value 1929	Area	Value[2]	Area	Value[3]	Area	Value[3]
	Acres	$	Acres	$	Acres	$	Acres	$	---Percent---	
Buffalo	11,485	23,754	2,084	9,732	588	-	14,157	33,486	22.5	21.5
Damon	9,068	18,970	1,540	5,770	427	-	11,035	24,740	17.5	15.9
Gowen	704	4,459	298	2,242	152	-	1,154	6,701	1.8	4.3
Cravens	3,729	13,584	690	2,980	680	-	5,099	16,564	8.1	10.6
Salonia	9,650	23,058	2,490	9,600	920	-	13,060	32,658	20.7	21.0
Degnan	7,335	15,048	1,010	5,365	960	-	9,305	20,413	14.8	13.1
Red Oak	6,608	16,632	1,119	4,550	1,493	-	9,220	21,182	14.6	13.6
Total	48,579	115,505	9,231	40,239	5,220	-	63,030	155,744	100.0	100.0
Percent of total area	77		15		8		100		-	

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[1] Data from county tax rolls and "Sale records."

[2] No data available on assessed value of these properties.

[3] Exclusive of assessed values of properties acquired in 1926 or prior years. These totals, of course, represent merely the numerical sums of values assessed in 1929 and 1935, rather than assessed values as of any one year.

More than three-fourths of the total forfeited area now in county ownership was acquired in 1936, while 15 percent was bought in 1930, and only 8 percent in 1926 or earlier. This relationship exists, of course, because the county has disposed, through Commissioners' sales of much of the property acquired at the earlier resales. Data were not obtained on the total area or value actually bought by the county at any resale, but merely on that portion of such acquisition remaining in county title in May 1938.

The 63,030 acres now owned in fee by the county represent 13 percent of the 470,400 acres comprising the gross area of the county, or 15 percent of the otherwise taxable area (423,600 acres). The tax-exempt area of the county includes the following:

Unappropriated Federal public domain	5,020 acres
State-owned lands (parks)	6,450 acres
Exempt Indian allotments (estimated)	35,000 acres
Other constitutionally exempt lands	330 acres
Total	46,800 acres

Thus approximately 109,800 acres (23 percent of the county's area) are now off the tax-roll.

In table 3 the 63,030 acres now owned by Latimer County are classified by year of original delinquency, that is, the first year for which taxes were unpaid. For example, properties on which taxes for 1932 were not paid (but on which all previous taxes had been paid), and which were "bid in" at the 1933 tax sale and bought by the county at the 1936 resale, are classified under "1932."

Table 3.- Tax delinquency, by year of original delinquency of lands in county title, May 1938, Latimer County, Oklahoma[1]

Year of original delinquency[2]	Area in acres	Percent of total
1919 or earlier	185	0.3
1920	560	0.9
1921	1,773	2.8
1922	299	0.5
1923	1,865	3.0
1924	870	1.4
1925	1,984	3.1
1926	1,695	2.7
1927	5,951	9.4
1928	10,298	16.3
1929	12,707	20.2
1930	6,636	10.5
1931	8,716	13.8
1932	4,271	6.8
Unknown[3] (1922 or earlier)	5,220	8.3
Total	63,030	100.0

[1] Data from county tax rolls for 1935 and 1929, and from "Sale records."

[2] The first year for which the taxes were unpaid; on almost all tracts, delinquency has since been continuous.

[3] Derived from resales of 1926 or earlier years.

It is evident from these data that delinquency of a long-term nature has arisen in Latimer County considerably before the beginning of the recent general depression. Only 31 percent of the forfeited area was derived from delinquencies originating from 1930 to 1932 inclusive; the preceeding three-year period (1927-1929), coincident with the peak of national prosperity, accounted for 46 percent of the total; and the remaining 23 percent was derived from still earlier delinquencies.

While no detailed study of the causes of delinquency was included in this investigation, the data which have been presented for Latimer County, along with observation of conditions there, permit at least a broad estimate of the primary causes. It is estimated by the county officials that 90 to 92 percent of the forfeited area is "wild, mountain land, chiefly suitable for timber"—in other words, forest land. The removal of the last large volume of currently merchantable timber and the exhaustion of profitably exploitable coal veins—two developments which coincided in the period 1926-1930—undoubtedly were major factors in causing the forfeiture of much of the mountain area of the county. Moreover, since one of the chief markets for local timber was the coal mines, the latter's decline accentuated the difficulty of disposing of second-growth timber, generally of low grade, which could not compete in outside markets with better timber from other regions.

It is the opinion of many of the leading citizens of the county seat, including some of the county officials, that public ownership for forestry purposes of the forfeited mountain lands is the only economically sound solution of the problem of their delinquency. The writer shares this viewpoint.

Adair County

Adair County lies in the upland hardwood region of the Boston Mountains, on the westward extension of the Ozark Plateau in northeast Oklahoma (fig. 1). The topography is hilly to mountainous, except in the northeastern fourth of the county, where it is level to rolling. Elevations range from 1,000 to 1,800 feet above sea level. The principal species on the forest land, which comprises about 62 percent of the county area, are red, white, post, black, and blackjack oaks, hickory, elm, gum, black walnut, and shortleaf pine. The harvesting and manufacture of minor forest products is the chief industry, ties, handles, and cooperage being the principal products. Stilwell, the county-seat, is the largest tie-exporting station on the Kansas City Southern Railroad between Kansas City and Port Arthur, Texas.

The southern and western parts of the county have the roughest topography and are rather poorly equipped with roads except for U. S. Highway #59 and State Highway #51. The northern half of the county is well supplied with Federal highways, and is served by both the K.C.S. and Frisco Railroads.

The gross area of the county is 373,760 acres, and its 1930 population was 14,756, or 25 persons per square mile. About 35 percent of the population is Indian, chiefly Cherokees. In 1934, only 67,118 acres were in cultivation, while farm woodlands were found on 82,687 acres.[12]

This county, originally part of the Cherokee Nation, has suffered from the weird ownership pattern evolved by the Dawes Commission (1905-06), which allotted lands to the Cherokees prior to the establishment of State government over all of what is now the State of Oklahoma.[13] A discussion of the history of these allotments is not within the scope of this report, but it is important to know the results. Briefly, the Dawes Commission allotted to each "full- or three-quarter-blood" Cherokee $325 worth of land at the value per acre appraised by the Commission, including a homestead. The acreage represented by the difference between the appraised value of the homestead and the $325 total was allotted in 10-acre tracts scattered wherever unallotted acreage could be found, quite irrespective of quality of land or contiguity of ownership. Involved regulations dealing with the alienation of title of these allotments were imposed, and are still in effect.[14] As a result, throughout Adair and ajoining counties of the old Cherokee Nation there are thousands of 10-acre tracts with extremely scrambled ownership and tax status. About 33,500 acres of allotted land is still tax-exempt, while the net rural taxable area of the county is 338,800 acres.

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[12] U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

[13] Oklahoma was admitted to the Union in 1907. Prior to the adoption of a State constitution, it consisted of Indian Territory (approximately the eastern fourth) and Oklahoma Territory (the remainder of the State).

As in Latimer County, corporation property now makes up the largest single item of the tax base in Adair County. In 1937, corporation property (almost exclusively the property of the two railroad companies) comprised 46 percent, real estate 42 percent, and personalty 12 percent of the total assessed value (table 4). Also as in Latimer County, real estate during the last decade has declined in importance as a factor in the tax base, while corporation property has increased. In 1928, corporation property formed less than 40 percent of the total value. An unusual feature of the assessment trends in Adair County from 1934 to 1937, is the increase, both in absolute amount and in relative percentage of the tax base, in the value of personal property. Urban property (real and personal), however, declined both in absolute amount and in relative percentage of the tax base (from 15.0 percent in 1934 to 12.8 percent in 1937). The total assessed value of the county declined nearly $2,000,000 (41 percent) during the past decade, presumably as a result of (1) decline in actual value, as reflected in lowered assessments on all property, and (2) the practice of making sharp reductions in the assessments of delinquent land bid in by the county tax sales (see page 5).

Data are also presented in table 4 on the assessed values of each civil township. In this connection it should be noted that the towns of Westville (pop. 691), Watts (pop. 353), and Stilwell (pop. 1,366) which lie in Westville, Ballard, and Stilwell Townships, respectively, increase the assessed values of surrounding rural property in these townships.

There is no land in Adair County in county title through forfeiture for taxes. A courthouse fire in 1929 destroyed all existing records, and all land then in county ownership was sold by commissioners' deed to one speculator. Incidentally, every acre of it is again eligible for resale. No resales have been held since the fire, but a tax sale was held in November 1935, which acted as a cumulative sale of delinquent taxes of 1929 to 1934 inclusive. Property bid in by the county at that tax sale was technically eligible for resale in April 1938, but as no resale has been held it can be offered again in 1939. Since no tax sale has been held since 1935, no other lands were eligible for resale as of the date of this study.[15/] In this county, owing to the presence of delinquent undivided fractional interests in certain real estate, the county holds tax liens on fractional interests in a few properties, as well as full interest in many more.

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[14] Much of the history of this movement was supplied the writer by John H. Leeper, Abstractor and life-long resident of Adair County, who served as advisor to the Commission. See also: Beckett, A. L. Know your Oklahoma. Harlow Publishing Co., Oklahoma City. 183 pp. 36 tables. 1930.

Table 4.- Changes in assessed values, 1928 - 1937, Adair County, Oklahoma[1/]

Civil township or town	1934			1937		
	Real estate	Personalty	Total	Real estate	Personalty	Total
Civil townships			Dollars			
Ballard	159,144	22,709	181,853	129,804	18,539	148,343
Chance	119,490	14,273	133,763	108,078	18,474	126,552
Westville	188,905	27,347	216,252	137,974	33,846	171,820
Baron	127,710	23,332	151,042	99,023	28,772	127,795
Wauhillau	112,815	21,132	133,947	77,551	28,672	106,223
Christie	97,375	17,751	115,126	81,956	23,877	105,833
Stilwell	162,830	22,661	185,491	115,686	22,702	138,388
Bunch	122,495	29,573	152,068	97,115	35,462	132,577
Lees Creek	82,735	11,586	94,321	87,050	12,449	99,499
Total rural	1,173,499	190,364	1,363,863	934,237	222,793	1,157,030
Towns						
Westville	144,670	49,686	194,356	85,602	30,210	115,812
Watts	34,856	9,675	44,531	22,293	6,919	29,212
Stilwell	192,360	80,693	273,053	134,638	81,981	216,619
Total urban	371,886	140,054	511,940	242,533	119,110	361,643
Total	1,545,385	330,418	1,875,803	1,176,770	341,903	1,518,673
All corporation property in county	-	-	1,534,948	-	-	1,299,613
Grand total	-	-	3,410,751	-	-	2,818,286

	1928	1932
Real and personal	$2,883,173	Unknown
Corporation	1,878,865	"
Total	4,762,038	$3,492,302

[1/] Data for 1934 and 1937 from county assessment rolls; for 1928 from Report of State Auditor for fiscal year ending June 30, 1928. Total assessed value for 1932 from U. S. Bureau of the Census. Realty Tax Delinquency. Vol. I. Current Tax Delinquency by States and Counties; Levies of 1932-1933. Washington. 1934.

[15/] No land can be offered at resale unless a valid tax certificate on that particular tract has been outstanding for at least 2½ years.

As of May 1938, there was eligible for resale a total of 99,241 acres on which the county's tax lien covered full interest, and in addition the county held liens covering fractional undivided interests in a gross area of 1,563 acres, the weighted-average interest being approximately 58 percent, equivalent to full interest on 908 acres (table 5). The total area (actual full-interest area plus equivalent full-interest areas) eligible for resale was 100,149 acres, or 27 percent of the total area of the county. The total delinquent area is 29 percent of the net taxable rural area (338,800 acres). Approximately 133,600 acres are off the tax roll, either through delinquency or by statutory exemption, an area equivalent to 36 percent of the gross area of the county!

As in Latimer County, and also as found in a previous study in Washington County, Arkansas [16], which adjoins Adair County on the east, a close relationship is shown in Adair County between topography (as a factor in land use and accessibility) and degree of delinquency. The civil townships with the largest percent of their area delinquent are, in order, Lee's Creek, Christie, Chance, and Bunch, each of which had 30 percent or more of its area delinquent (table 5). These are the roughest, most sparsely settled, and most inaccessible townships of the county. The townships with the least delinquency—Westville and Ballard, each with less than 18 percent of its area delinquent—consist largely of level to rolling prairie and contain the towns of Westville and Watts, respectively.

As of 1934 (last assessment prior to tax sale), the assessed value of the 99,241 acres on which the county holds full interest liens was $210,463. The delinquent fractional interests were assessed for $1,380, to bring the total assessment of delinquent properties to $211,843, or 18 percent of the assessed value of all rural real estate (table 5). These data indicate, as might be expected, that the lower-value properties are more involved in delinquency, since the percentage of value delinquent is only two-thirds of the percentage of area delinquent (18 and 27 percent, respectively). While slight changes are noted in the order of townships by degree of value delinquency as compared with their order by area delinquency, the four townships which have the greatest percent of their area delinquent also have the greatest percent of their value delinquent.

Data on trend in delinquency are available in this county only from 1929 to the last year of assessment prior to tax sale (1934). The trend shown is somewhat similar to that in Latimer County (table 3), but the different lengths of time covered by the two tables prevent an accurate comparative analysis. The sharp decline in area arising from delinquencies of 1933 and 1934, as compared with that derived from earlier years, is difficult to explain without a more detailed study than the present investigation warranted. It might be expected (as has been found in delinquency studies in other States[17]) that the portion of present delinquent area derived from nonpayment of taxes due in years immediately preceding the time of study would be greater than the portion derived from unpaid taxes of earlier years, since the latter taxes

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[16] Craig, Ronald B., and Orville J. Hall. Tax delinquency of forest land in Arkansas. Ark. Agric. Exp. Sta. Bull. 340. Fayetteville, 1937.

[17] Cf. bulletin cited above, and Craig, Ronald B. Taxation of Forest Land in the Yazoo Delta of Mississippi, Occasional Paper #74, Southern Forest Exp. Sta. New Orleans, 1938. Similar trends have been shown in unpublished studies of tax delinquency in Louisiana and Florida.

Table 5.- Area and assessed value of land eligible for resale as of April 1938, Adair County, Oklahoma[1]

County holds lien on fractional undivided interest

Civil township		Partial interest on gross area shown[2]	Equivalent full-interest area[3]		Assessed value of interest only, 1934	
		- - - - Acres	- - -		Dollars	
Ballard		0	0		0	
Chance		0	0		0	
Westville		0	0		0	
Baron		0	0		0	
Wauhillau		143	47		120	
Christie		40	32		55	
Stilwell		0	0		0	
Bunch		680	340		560	
Lee's Creek		700	489		645	
County		1,563	908		1,380	

County holds lien on full interest

Civil township	(1) Gross area of township	(2) Delinquent rural area 1938	(3) Ratio of delinquent to total area	(4) Assessed value - 1934 - all rural real estate	(5) Assessed value - 1934 - area shown in col.(2)	(6) Ratio of delinquency to total value
	- - - -Acres	- - - - -	Percent	- - - Dollars	- - - - -	Percent
Ballard	30,269	5,400	17.8	159,144	21,395	13.4
Chance	46,080	14,013	30.4	119,490	27,490	23.0
Westville	29,340	3,598	12.3	188,905	13,135	6.9
Baron	39,245	7,129	18.2	127,710	19,795	15.5
Wauhillau	41,600	9,866	23.7	112,815	25,370	22.5
Christie	40,320	12,992	32.2	97,375	22,767	23.4
Stilwell	25,442	4,963	19.5	162,830	20,350	12.5
Bunch	60,160	17,826	29.6	122,495	29,320	23.9
Lee's Creek	61,304	23,453	38.3	82,735	30,841	37.3
County	373,760	99,241	26.6	1,173,499	210,463	18.0
Grand total	373,760	[4]100,804	26.8	1,173,499	211,843	18.1

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[1] Data from county tax rolls and "Sale records."

[2] County holds varying fractional interests (1/2, 1/3, 1/5, etc.) on gross area shown in this column.

[3] Areas shown represent product of fractional interest and gross area, weighted.

[4] Equivalent to full interest on 100,149 acres (99,241 acres plus 908 acres).

(or the lands on which they were levied) have been subject to redemption or sale for a longer period than those recently delinquent. This trend, however, is not followed in either Latimer or Adair Counties. A possible explanation may be the proscription of tax sales in 1933 by Executive Order of the Governor, and the legislative abatements of penalties and extensions of redemption period in 1933-34. Also there is a possibility that most of the "submarginal" areas were already delinquent before 1933, and that improved agricultural conditions operated to prevent wholesale delinquency on the better lands after that date. Value data are not presented in table 6, since assessed values were obtained only for 1934 on all tracts, not as of the date of last assessment prior to original delinquency of each separate tract.

Table 6.- Tax delinquency by year of original delinquency, as of May 1938, Adair County, Oklahoma[1]

Year of original delinquency	Area[2]	Percent of total
	Acres	Percent
1929	36,977	37
1930	16,296	16
1931	10,644	11
1932	27,238	27
1933	6,684	6
1934	2,955	3
Unknown	10	[3]
Total	100,804	100

[1] Data from county tax rolls and "Sale records."
[2] Including tracts on which county lien covers only fractional interest, given here by gross area of tracts in which interest lies.
[3] Less than 0.5 percent.

Creek County

Creek County lies in the Eastern Cross Timbers region of Oklahoma, south of the Arkansas and Cimarron Rivers (fig. 1). The topography is gently rolling to hilly, the elevations ranging from 700 to 1,200 feet above sea level. Extensive areas of upland prairie are separated by large, irregular areas of forest composed largely of scrub hickory and post, blackjack, and southern red oaks. About 27 percent of the county is forest land. Oil and gas production is a major industry, but agriculture is important.

The gross area of the county is 616,680 acres, and its 1930 population was 64,115, or 67 persons per square mile. Creek County contains six incorporated cities or towns with a total population in 1930 of 25,545, or 40 percent of the total population. In 1934 there were 157,842 acres in cultivation, while only 26,000 acres were in farm woodlands.[18]

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[18] U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

As its name implies, this county lies in the old Creek Nation, and the Indian allotments, with a few exceptions along the Cimarron River, were in quarter-sections. Hence a more usual type of area-ownership pattern is found than in Adair County.

In Creek County, real estate has consistently formed the largest percentage of the total tax base, although in 1937 it comprised only 1 percent more than corporation property (table 7). Both real estate and corporation property have formed a decreasing percentage of the tax base since 1935, while personalty has formed an increasing percentage.

Table 7.- Changes in assessed values,1/ 1928 - 1937,
Creek County, Oklahoma

Assessment year	Real estate		Personal property		Corporation property		Total	
	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total
	Dollars		Dollars		Dollars		Dollars	
1928	2/	-	2/	-	12,668,426	27	45,958,534	100
3/1935	10,785,154	43	3,902,737	15	10,633,392	42	25,321,283	100
3/1936	11,724,033	43	4,512,141	17	10,780,420	40	27,016,594	100
3/1937	11,459,010	40	6,012,660	21	11,085,595	39	28,647,265	100

1/ The total assessed value as of 1932 was $31,865,030, according to U. S. Bureau of the Census. Realty Tax Delinquency. Vol. 1. Current Tax Delinquency by States and Counties, Levies of 1932-1933. Washington, 1935.

2/ Data from Report of State Auditor for fiscal year ending June 30, 1928. The breakdown between realty and personalty is not available. Total was $33,290,108, or 73 percent of total value.

3/ Data from county assessment rolls.

While the total tax base has declined 38 percent ($17,311,269) since 1928, there has been an increase since 1935 of 13 percent ($3,325,982), but note should be taken of the State-wide reduction of 20 percent in values ordered in 1932 by the State Board of Equalization. All items have shown an increase over this 2-year period, but real estate declined slightly (both in amount and in percentage of total) from 1936 to 1937. A surprising feature of the trend in values is the 54 percent increase in value of personal property since 1935, possibly accounted for by a recent expansion in the oil and gas industries in the established fields in Creek County.

Creek County has not held a resale since 1930, previous resales having been held in 1928, 1927, 1926, 1924, and 1922. A tax sale was held in November 1936, when all properties on which taxes were delinquent (including all those delinquent since 1931, plus those unearthed by a "tax ferret" and going back to 1911) were offered for "sale." Properties bid in by the county at that tax sale, and as yet unredeemed, will be eligible for resale in April 1939. They are treated in this report exactly as are those properties which were eligible for resale in April 1938.

The tax status of rural land in this county is complicated not only by lack of recent resales and by the widespread exemption of lands allotted to Indians, but even more by the extremely complex vesting of title in fractional undivided interests in oil and gas lands, leases, and royalties, secured by mortgage or other liens, and in other rights, surface and subsurface. On one tract of 16-2/3 acres there are 2,814 undivided interests! Since, in many cases, the taxes on some of these undivided interests are delinquent and on others are paid, the county tax liens, as represented by outstanding tax certificates, are frequently representative of only fractional interests in any one tract or series of tracts. In addition, the county has title in fee, acquired at resales of 1930 or earlier years, to full interest in certain tracts and to partial interest in other properties. Still further complicating the picture of extent of delinquency in Creek County is a printer's error in the advertising of delinquent tracts for the 1936 tax sale, whereby some 7,000 acres in one township were omitted from the published list, thereby preventing their being offered for sale, even though they were delinquent and otherwise subject to sale.

Creek County holds title in fee to full interest on 5,577 acres, and holds fee title to undivided fractional interests in an additional area of 490 acres (table 8). The fractional interests held are approximately equivalent to full interest on 240 acres, to bring the area in county ownership, acquired at resale, to 5,817 acres. This area is equal to less than 1 percent of the gross area of the county and to slightly more than 1 percent of the net area taxable in 1937 (518,003 acres). Euchee Township, which has the largest area of county-owned land, is in the central part of the county, and is chiefly characterized by poor soils covered with scrub oak; while the other two townships having large areas in county ownership (Tiger and Mannford) are on the northern edge of the county and are among those in which the oil and gas industry is particularly active.

The area eligible for resale in April 1939, on which the county lien covers full interest, is 153,119 acres (table 9). In addition the county holds unredeemed tax liens on fractional undivided interests in an additional area of 15,658 acres. The fractional interests held are approximately equivalent to full interest on 6,480 acres, to bring the area eligible for resale to 159,599 acres. This area is equal to 26 percent of the gross area of the county and to 31 percent of the net area taxable in 1937.

All parts of the county are rather seriously involved in delinquency, but Newby, Euchee, Kelleyville, Mounds, and Mannford Townships have the largest areas eligible for resale. With the exception of Mannford, all these townships lie in the central part of the county, and are not particularly developed for gas and oil.

In addition to the areas in county ownership (table 8) and those eligible for resale (table 9), in a portion of Bristow Township there are 7,256 acres which are delinquent in fact, but which, through error, were omitted from the legal notice of the 1936 tax sale and hence are not eligible for resale.

The total area involved in some type of long-term delinquency, therefore, is 172,673 acres, an area equivalent to 28 percent of the gross area, and 33 percent of the net taxable area, of Creek County. Again, excluding the 7,256 acres in Bristow Township which, through error, are still subject to taxation (even though the taxes presumably are unpaid), it is evident that 264,089 acres (98,673 acres tax-exempt, plus 5,817 acres county-owned, plus 159,599 acres eligible for resale) or their equivalent (in fractional interests) are off the tax roll—an area equal to 43 percent of the gross area of the county!

Table 8.- Area and assessed value of land in county title, as of June 1, 1938, Creek County, Oklahoma[1]

County owns full interest in fee

Civil townships	1930 resale		1928 or earlier resales		Totals	
	Area	Assessed value 1929	Area	Assessed value 1927	Area	Assessed value
	Acres	Dollars	Acres	Dollars	Acres	Dollars
Sapulpa	288	9,775	0	0	288	9,775
Olive	60	730	0	0	60	730
Hazlip	440	5,850	0	0	440	5,850
Creek	260	4,170	0	0	260	4,170
Tiger	549	12,725	0	0	549	12,725
Mannford	542	8,536	2	[2]45	544	8,581
Mounds	106	2,960	40	600	146	3,560
Newby	400	8,000	0	0	400	8,000
Kellyville	399	5,985	0	0	399	5,985
Euchee	660	11,300	45	900	705	12,200
Bristow	456	7,812	0	0	456	7,812
Depew	460	14,200	0	0	460	14,200
Lakeside	240	4,700	0	0	240	4,700
Sunnyslope	356	5,515	13	190	369	5,705
Shannon	221	3,640	40	400	261	4,040
County	5,437	105,948	140	2,135	5,577	108,083
County owns fractional interest only						
Sapulpa	120	1,500	0	0	120	1,500
Hazlip	40	200	0	0	40	200
Kellyville	170	1,275	0	0	170	1,275
Euchee	120	1,500	0	0	120	1,500
Depew	40	200	0	0	40	200
County	[3]490	[4]4,675	0	0	[3]490	[4]4,675

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[1] Data from "Sale records" and tax rolls. These lands were acquired at resales of 1930, 1928, and 1927.

[2] Assessed value as of 1926.

[3] Gross area of tracts in which fractional interest lies.

[4] Assessed value of fractional interest only.

Table 9.- Area and assessed value of land eligible for resale in April 1939, Creek County, Oklahoma[1]

Civil townships	County's lien covers full interest		County's lien covers fractional interest[2]	
	Area	Assessed value - 1935	Area[3]	Assessed value[4] - 1935
	Acres	Dollars	Acres	Dollars
Sapulpa	7,002	100,448	1,375	5,895
Olive	7,016	65,356	920	4,006
Hazlip	8,055	63,466	721	2,573
Creek	6,842	55,797	1,265	4,125
Tiger	11,815	125,793	1,829	7,409
Mannford	13,439	139,166	515	3,060
Mounds	13,473	139,495	1,590	5,355
Newby	18,549	186,306	870	3,840
Kellyville	15,805	143,685	1,240	4,453
Euchee	18,007	161,406	640	3,380
Bristow	4,125	47,165	220	1,230
Depew	7,524	70,161	1,430	4,866
Lakeside	7,167	76,330	930	5,161
Sunnyslope	5,559	56,767	800	4,671
Shannon	8,741	85,605	1,313	4,200
County	153,119	1,516,946	15,658	64,224

[1] Data from "Sale records" and tax rolls. These lands were "bid in" by county at the 1936 tax sale.

[2] On these properties, the county's tax lien covers varying fractional undivided interests only.

[3] Gross area of properties in which fractional interests lie.

[4] Assessed value of fractional undivided interests only.

In terms of assessed values as of 1 year prior to the resales at which the property was forfeited to the county, the area in county title, including full interests and fractional interests, was worth $112,758 (table 8). That eligible for resale, again including both full and fractional interests, was assessed in 1935 (1 year prior to tax sale) at $1,581,170 (table 9). Data are not available on the assessment of the 7,256 acres in Bristow Township. Based on the average assessed value per acre in 1935 of other delinquent lands in this township ($11.43), they would be worth about $83,000. Hence the grand total of assessed values (irrespective of year of assessment) of all lands thus involved in delinquency is about $1,777,000. This total is 7 percent of the total 1935 tax base of the county, and more than 16 percent of the total assessed real-estate values.

The trend in delinquency in Creek County is slightly different from that in Latimer and Adair Counties. As shown in table 10, nearly 76 percent of the present outstanding delinquency has arisen since 1929; the peak year was 1930, closely followed by 1932 and 1935. Furthermore, while the general trend since 1930 has been downward, that trend is much more irregular than in the first two counties discussed. Evidently the effect of the depression has been more definitely reflected in tax delinquency in Creek than in Latimer and Adair Counties. In view of the chief industry of the county—oil and gas production—the depression, coupled with the fiscal history of the county, explains the trend in, and probably the cause of, the delinquency noted.

Table 10.- Tax delinquency, by year of original delinquency, as of May 1938, Creek County, Oklahoma[1]

Year of original delinquency	Area	Percent of total	Tax status
	Acres		
1911,1912, 1913,1919	641	0.4	54.5 acres in county title. Balance eligible for resale.
1921	2	[2]	In county title.
1922	138	0.1	
1923	10	[2]	
1924	40	[2]	
1925	2,899	1.7	
1926	3,206	1.8	2,859 acres in county title. Balance eligible for resale.
1927	2,724	1.6	Eligible for resale in 1939.
1928	13,288	7.6	
1929	19,127	10.9	
1930	31,161	17.8	
1931	21,887	12.5	
1932	28,212	16.1	
1933	13,015	7.5	
1934	14,896	8.5	
1935	23,475	13.4	
Unknown	123	0.1	63 acres in county title; 60 acres eligible for resale.
Total	174,844	100.0	

[1] All land now in county title for unpaid taxes, or eligible for resale in 1939, is classified by year of original delinquency. This includes gross areas of properties on which county now holds title or lien on fractional interest.

[2] Less than 0.05 percent.

Different causes operate in the delinquency of Creek County land than in that of the first two counties studied. A major cause (if not the primary one) is the speculative development in oil and gas lands, leases, and fractional interests—a recurring series of booms and deflations. As the inevitable concomitant of such booms, local governments—the county, townships, municipalities, and even school districts—floated large bond issues on inflated realty values, and when the boom burst were left with the incubus of a heavy debt, requiring debt-service taxes which, in some of the subdivisions of

Creek County, are definitely confiscatory. Indeed, millage rates in certain incorporated towns in this county reach astounding heights, while assessed values throughout the county are more an index of revenue needs than of true values. In the town of Slick (sic!), the total rate levied in 1937-1938 against every dollar of taxable value was 503.38 mills. Even in the surrounding rural area outside the town limits, the rate was 332.70 mills. Since the average assessed value of rural land in this same area is $8.96 per acre, the average annual tax was $2.98 per acre! The greater part of this plainly confiscatory levy is for debt service. The bonded debt of the town of Slick is 280 percent of its total assessed value. The average tax per acre on all rural land in the county is 50 cents per acre. Small wonder than 28 percent of the gross area of the county is involved in delinquency!

While much of the delinquency in the southern part of the county is on forest land, only about 35 percent of the total delinquent area in the entire county is of this type. Most forest areas involved in delinquency are covered with the scrub stand of blackjack oak typical of this portion of the Eastern Cross Timbers. Annual burning, together with poor sandy soil, has prevented the growth of the more valuable post and southern red oaks.

Beaver County

Beaver County, the easternmost county of the Oklahoma Panhandle, lies in the High Plains (fig. 1), but the topography is more rolling than in the High Plains to the west, since the eastern edge of the county lies on the "breaks," where the High Plains break down sharply to the Rolling Prairies. The Cimarron and North Canadian Rivers have cut deep valleys in the plain, which are marked, particularly in the case of the latter stream, by sandhills on the northern banks. Elevations range from 1,800 to 3,700 feet above sea level. The county is practically treeless, except along the streams, where cottonwood and willow are the chief species. Less than 1 percent of the county, therefore, is forest land. Cattle raising and wheat farming are the principal activities, although various sorghums are assuming importance as farm crops. The western part of the county particularly (and to a less extent, the eastern part) has suffered from the severe dust storms of 1932 to 1935.

The gross area of the county is 1,160,320 acres, and its 1930 population was 11,452, or 6 persons per square mile. Beaver, Forgan, and Elmwood are the only incorporated towns, all except Beaver (pop. 1,500) being less than 1,000 population. Railroad facilities are extremely limited; the one railroad that enters the county runs from the east border as far west as Forgan, or only half way across the county. Ninety-three percent of the county was in farms in 1934, and 547,025 acres were in cultivation.[19]

Beaver County has maintained a relatively stable tax base, subsequent to the state-wide uniform reduction in values ordered in 1932 by the State Board of Equalization (table 11). The sharp decline from 1932 to 1933, however, reflects the effect of the wheat-crop failure and livestock losses of 1932 on farm real estate and livestock values. The decline from 1937 to 1938 likewise reflects a distressed agriculture, as indicated by the extent of State School-Land Commission foreclosures, as explained hereafter. As in all counties so far discussed, corporation property forms an increasingly important element of the tax base, having advanced from 5 percent of the total value in 1928 to 28 percent a decade later. Real estate has declined in the past 8 years from 81 percent of the tax base to 66 percent, although it remained at approximately 70 percent from 1931 through 1937. The total tax base has declined 43 percent ($7,219,910) from the 1931 peak, but only 9 percent since 1933.

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[19] U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

Table 11.- Changes in assessed values, 1928 - 1938, Beaver County, Oklahoma[1]

Year	Real estate		Personalty		Corporation		Total
	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total	Amount
	Dollars		Dollars		Dollars		Dollars
1928	[2]	-	[2]	-	[2]695,943	5	[2]15,093,933
1930	12,710,546	81	2,071,779	13	899,977	6	15,682,302
1931	11,856,025	70	1,595,127	9	3,369,982	21	16,821,134
1932	9,415,040	71	1,045,008	8	2,721,451	21	13,181,499
1933	7,484,289	71	615,433	6	2,442,835	23	10,542,557
1934	7,484,289	71	577,957	5	2,451,148	24	10,513,394
1935	7,476,508	71	597,549	6	2,442,607	23	10,516,664
1936	7,476,508	70	743,192	7	2,399,509	23	10,619,209
1937	7,425,578	70	749,878	6	2,574,997	24	10,750,453
1938	6,379,991	66	603,508	6	2,617,725	28	9,601,224

[1] Data from county assessment rolls, except for 1928.
[2] Data from Report of State Auditor for fiscal year ending June 30, 1928. Total real and personal property valuation is $14,397,990, or 95 percent of the total value.

Beaver County has held no resale since April 1931; the last preceding resale was in 1927. Tax sales were held (since last resale) annually through 1935, but none was held in 1936 or 1937, owing to technical procedural defects occasioned by legislative extensions of delinquency dates. In this, as in all the other counties discussed thus far, delinquent taxes accruing on tracts on which tax certificates are already outstanding in the hands of the county are endorsed on these certificates, together with accrued penalties and costs. Hence all properties bid in by the county at the tax sales of 1931 to 1935 inclusive, and unredeemed, were technically eligible for resale in April 1938, but since no resale was held, they can be offered again in 1939. Beaver County already has title to six tracts of 40 acres each (240 acres) acquired at the 1931 resale and not yet sold by the County Commissioners.

Another factor of importance in several counties, but particularly acute in the Panhandle (of which Beaver is a representative county) is the extent to which the State has acquired title to rural lands through foreclosure of loans or leases made by the School-Land Commission. Originally, two sections (16 and 36) out of each survey township were set aside as State School-Land, the Commission being allowed to lease, but not sell, these sections. In 1934, however, the law was amended to permit sale of school lands, provided all proceeds from sale or lease were segregated in the School-Land Commission Fund. The Commission can, from this fund, make loans (with privilege of purchase) to farmers, secured by a first mortgage on the farm. It can also exchange State school-lands in sections 16 and 36 for land in other sections, and, as heretofore, can lease school-lands. Failure of the mortgagee or lessee to keep up his payments results, of course, in foreclosure and in revesting of title in the State. In Beaver County, the State now holds fee title (tax exempt, of course) to 41,694 acres, or nearly 4 percent of the gross area of the county, all of which is in the hands of the School-Land Commission either because it has never been sold or leased, or because the State has foreclosed a mortgage or lease. Furthermore, since such property (or the lease) becomes taxable when sold or leased, foreclosure by the State of either type of instrument, when delinquent taxes have accrued on the property, results in a loss to the county of all such taxes, penalties, and costs, for the State at present makes no reimbursement to the county. The county, under present law, is estopped from enforcing collection from the State, since the sovereign cannot be taxed by one of its subdivisions. Inasmuch as failure to meet interest or lease payments is almost certain to be concomitant with failure to meet tax payments, foreclosure by the State in almost every case causes considerable loss to the county. When such foreclosure reaches the extent it has in Beaver County, the loss of tax revenue becomes an important factor in local financial stability.

Also exempt from taxation are 1,400 acres of unappropriated Federal public domain, and 1,188 acres[20/] of constitutionally exempt land. Hence the total area exempt from taxation (Federal, State, and county land, and other constitutionally exempt land) is 44,282 acres.

As of October 1938, there were 111,494 acres in Beaver County eligible for resale (table 12). This area, which is equivalent to nearly 10 percent of the gross area of the county, is segregated in the table by year of tax sale, since, as previously noted, there are no duplications of sales of the same tract and each sale represented tracts not previously bid in by the county. This does not imply, however, that none of these tracts was previously involved in delinquency between 1931 and 1935. In fact many of them, particularly those shown for the 1934 and 1935 sales, had been delinquent earlier in this 5-year period, had been redeemed, and had again become delinquent. The extent of this redelinquency will be discussed later. The same decrease in delinquency since 1931 is to be noted here that was found in the other counties. As in Creek County, however, there was an increase from 1934 to 1935, but it was not sufficient to bring the 1935 total up to that for 1933 or earlier years.

Geographically, the bulk of the delinquency is concentrated (with the exception of that in Kokomo Township) in the south-central and southeastern parts of the county. That in Kokomo Township lies mostly in the wide belt of sand hills along the north side of a great bend in the North Canadian River, and in the rough arroyos coming into the valley from the South. The concentration of the bulk of the remaining delinquency in the eastern part of the county may appear contradictory to the statement previously made that this part of the county had suffered much less severely from dust storms than the western half. While the latter statement is true, as any observer can determine even by casual inspection, the increased delinquency in the

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[20/] Including 240 acres in county title through purchase at resale of 1931.

Table 12.- Area and assessed value of land eligible for resale in April 1939, classified by year of tax sale, Beaver County, Oklahoma[1]

Civil townships	1935		1934		1933		1932		1931		Total	
	Area	Value 1934	Area	Value 1933	Area	Value 1932	Area	Value 1931	Area	Value 1930	Area	Value[2]
	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars
Grand Valley	800	4,987	680	3,776	960	6,636	1,640	15,865	1,440	13,665	5,520	44,929
Nabisco	960	5,335	1,120	10,008	448	5,260	1,680	20,300	1,102	15,160	5,310	56,063
Balko	1,196	8,815	640	4,831	2,360	24,868	1,440	18,180	2,281	31,340	7,917	88,034
Kokomo	1,680	9,750	2,880	16,535	3,881	31,720	3,478	30,875	2,240	20,120	14,159	109,000
Floris	880	7,980	622	4,116	2,280	22,696	3,440	44,980	960	13,120	8,182	92,892
Elmwood	2,240	13,305	1,360	7,115	1,240	12,096	3,315	32,505	5,877	58,720	14,032	123,741
Beaver	1,440	9,615	1,440	11,695	2,173	20,196	2,320	24,005	3,520	43,700	10,893	109,211
Logan	1,080	8,015	1,200	7,026	1,040	9,204	2,760	28,675	3,200	31,660	9,280	84,580
Benton	3,000	14,825	1,840	8,604	1,440	9,800	2,201	19,860	4,247	38,060	12,728	91,149
Knowles	1,800	8,805	480	1,877	960	9,444	880	8,890	560	7,550	4,680	36,566
Blue Grass	2,880	21,622	1,000	8,254	2,375	20,612	2,744	24,440	1,812	17,420	10,811	92,348
Gate	327	2,375	80	444	906	7,052	1,040	4/10,900	2,670	25,030	5,023	4/45,801
Garland	795	3,660	1,211	3,792	280	3/424	534	5/ 490	99	500	6/2,959	7/ 8,866
County	19,078	119,089	14,553	88,073	20,343	3/180,008	27,472	8/279,965	30,008	316,045	111,494	9/983,180

1/ Data from county tax rolls and "Sale records," as of October 1938.
2/ Sum of values, for different years shown.
3/ Value data missing on 200 acres.
4/ Value data missing on 160 acres.
5/ Value data missing on 480 acres.
6/ Includes 40 acres, value unknown, delinquent since 1927 but not sold in 1931 resale.
7/ Value data missing on 720 acres.
8/ Value data missing on 640 acres.
9/ Value data missing on 880 acres.

eastern half of the county, according to local authorities, is occasioned by the much lower productivity of the soil in the rougher breaks that characterize this part of the county. Certainly from the topographic standpoint (as reflected in the character of the terrain) the eastern, and particularly the southeastern, part of the county is much less suitable for either wheat farming or stock raising than the wind-blown soils of the "Dust Bowl" to the west.

The total assessed value (irrespective of year of assessment, and less the value of 880 acres for which assessment data are lacking) of the 111,494 acres eligible for resale is $983,180 (table 12). This total is equivalent to 9 percent of the total 1935 tax base, or 13 percent of the total value of real estate in that year. Its ratios to the total tax base and real estate base of 1938 are 10 percent and 15 percent, respectively.

The extent to which the 111,494 acres eligible for resale reflect "original delinquency" is shown in table 13. The properties whose areas and assessed values are shown in this table had been involved in but the one tax sale at which each was bid in by the county. Nothing is known or implied, however, as to their delinquency history prior to the 1931 resale. It is assumed that all tracts then (1931) eligible for resale were sold at that resale. For this reason, all tracts bid in at the 1931 tax sale for delinquent 1930 taxes are here considered as in the "original delinquency" category. Obviously, the more recent the tax sale (as 1935 sale of 1934 taxes) the greater will be the opportunity, within the limitations of time just specified, for a tract to be involved in redelinquency. This accounts for the downward trend from 1930 to 1934 in the ratio of area involved in "original delinquency" for each year to total area "sold" for the taxes of that year. For example, only 5,802 acres (30 percent) of the 19,078 acres "sold" in 1935 (for the 1934 taxes) were delinquent for the first time in 1934, while the remaining 13,276 acres (70 percent) had been previously delinquent for at least 1 year during the 5-year period. On the other hand, as stated above, all the 30,008 acres sold in 1931 (for 1930 taxes) were delinquent for the first time in 1930 (so far as the survey determined). Of the total area eligible for resale, 23 percent (25,458 acres) had been involved in redelinquency during this period. The total assessed value of this area (last column total, table 12, minus last column total, table 13) is $176,228, or 18 percent of the total assessed value of all properties eligible for resale, indicating that it is the properties of lower value that are involved in redelinquency.

Oddly enough, however, comparison of the data in tables 12 and 13 shows that the civil townships with the greatest degree of redelinquency are, in descending ratio of redelinquent area to total area eligible for resale, Nabisco, Knowles, Benton, and Floris. With the exception of Benton, these townships are among those with the smallest total area eligible for resale. A definite reason for this somewhat paradoxical situation cannot be given on the basis of data and knowledge available to the writer, but the explanation may be that the properties that are eligible for resale in these three townships are those which are so badly involved in tax default, or are so poor in productivity and usefulness, that they are beyond restoration to taxpaying status by private means, whereas the remainder (the majority) of the properties in the same townships are, in general, supermarginal.

Table 13.- Area and assessed value of land eligible for resale that was involved in delinquency for the first time in year indicated, Beaver County, Oklahoma[1]

Civil townships	Year of original delinquency [2]										Total	
	1934		1933		1932		1931		1930			
	Area	Value[3]	Area	Value[3]	Area	Value[3]	Area	Value[3]	Area	Value[3]	Area	Value[4]
	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars
Grand Valley	160	1,000	160	926	960	6,636	1,640	15,865	1,440	13,665	4,360	38,092
Nabisco	0	0	80	691	448	5,260	1,360	17,165	1,102	15,160	2,990	38,276
Balko	720	5,055	320	2,073	2,360	24,868	1,440	18,180	2,281	31,340	7,121	81,516
Kokomo	640	3,775	1,640	9,489	3,761	31,256	3,478	30,875	2,240	20,120	11,759	95,515
Floris	160	1,160	80	448	1,560	16,428	2,960	38,955	960	13,120	5,720	70,111
Elmwood	880	5,040	80	450	1,240	12,096	3,155	31,080	5,877	58,720	11,232	107,386
Beaver	800	5,845	960	8,359	1,533	13,356	2,000	19,405	3,520	43,700	8,813	90,665
Logan	0	0	1,040	6,566	1,040	9,204	2,600	27,325	3,200	31,660	7,880	74,755
Benton	640	3,410	960	4,090	480	3,400	2,201	19,860	4,247	38,060	8,528	68,820
Knowles	240	1,440	320	1,417	760	7,408	880	8,890	560	7,550	2,760	26,705
Blue Grass	840	4,890	840	7,557	1,575	13,004	2,744	24,440	1,812	17,420	7,811	67,311
Gate	327	2,375	80	444	586	4,860	880	[6]8,470	2,670	25,030	4,543	[6]41,179
Garland	395	1,415	1,211	3,792	280	[5]424	534	[7] 490	99	500	2,519	[8]6,621
County	5,802	35,405	7,771	46,302	16,583	[9]148,200	25,872	[9]261,000	30,008	316,045	86,036	[10]806,952
Ratio to total eligible for resale [11]	30		53		82		94		100		77	

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[1] Data from county tax rolls and "Sale records," as of October 1938.

[2] One year prior to year of the tax sale at which each property here included was "sold" to the county for the first time since 1930. Nothing is known or implied as to delinquency history prior to 1930. All properties not included in this table had been involved in two or more tax sales held between 1931 and 1935, but the above properties had been involved in only one such sale.

[3] Value is as of year shown in same column heading in each case.

[4] Sum of assessed values, for different years shown.

[5] Value data missing on 200 acres.

[6] Value data missing on 160 acres.

[7] Value data missing on 480 acres.

[8] Value data missing on 680 acres.

[9] Value data missing on 640 acres.

[10] Value data missing on 840 acres.

[11] Ratio of "original delinquency" total of each year (table 13) to corresponding grand total of each year (table 12).

In addition to the area here recorded as eligible for resale in 1939, there are 41 tracts totalling 7,810 acres, which, while delinquent for more than 2½ years, cannot be offered at resale, since the presently outstanding tax certificates have been cancelled in order to permit the county treasurer to advertise delinquent taxes accrued prior to, and not included in, the present certificates. These tracts were "sold" at the 1938 tax sale, and if bid in by the county, will be eligible for resale in 1941.

Tillman County

Tillman County lies in the Rolling Prairie region along the upper Red River in southwestern Oklahoma (fig. 1). The topography is level except for the sand-hills area in the southwestern part of the county, on the north bank of the Red River, and on the east bank of the North Fork. This is one of the richest agricultural counties of the State, cotton, corn, wheat, and livestock being the principal products. Recently oil and gas developments have added another source of income.

The gross area of the county is 553,600 acres, and its 1930 population was 24,390, or 28 persons per square mile. More than 96 percent of the county was in farms in 1934, and 367,907 acres were in cultivation. Less than 3 percent of the county is forest land, chiefly along Cache Creek in the southeast part of the county.

Tillman County was selected in the original plans for this study as representative of southwest Oklahoma. Analysis of delinquency conditions there, however, indicated that a detailed survey was not justified. The last resale in Tillman County was held in 1931, and the last "annual" tax sale in 1930. Since no delinquent tax certificates are outstanding, there is no land eligible for resale, and no plans are being made to hold a tax sale in the near future.

This failure to comply with the statutes is justified, to some degree, by the very small area involved in either chronic or current delinquency. Of the land bought by the county at the 1931 resale, only about 175 acres remain in county ownership. This area is in small, scattered tracts, none of more than 40 acres, and much of it is lying in the bed of the River or in the adjacent sand hills. Land which is currently delinquent (i.e., for 1936 or 1937 taxes) does not total more than 1,200 acres in the county, while that which is delinquent for more than 2½ years (i.e., beyong the redemption period) is less than 600 acres. Hence tax delinquency in Tillman County is practically non-existent. The reason for this rather unusual condition is undoubtedly the high productive capacity of the soils, the well-developed local markets, and the relatively low taxes.

Jackson County

Jackson County lies northwest of Tillman County (fig. 1) and was selected as a typical southwestern Oklahoma County to replace Tillman when the latter was found not to warrant a detailed survey.

The topography is very flat except for a few isolated granite buttes in the extreme northeast part of the county, low sand hills along the Red River, and the shallow valley of Salt Fork. Cotton, corn, wheat, sorghums, and livestock are the principal products. Oil and gas are also being developed in several parts of the county. Altus, the county seat, and the metropolis of southwest Oklahoma, is a railroad and trade center, with a 1938 population of more than 9,000.

The gross area of the county is 497,920 acres, and its 1930 population was 28,910, or 37 persons per square mile. In 1934, nearly 95 percent of the county was in farms, and 337,764 acres were in cultivation.[21] Less than 1 percent of the county is forest land.

The tax base of Jackson County, like that noted in Beaver County, showed a sharp decline during the early years of the depression, which was emphasized further by the arbitrary reduction ordered by the State in 1932, but it has been relatively stable since that date (table 14). The decline in total assessed value from 1929 to 1938 was $7,262,831, or 42 percent; but the decline from 1933 to 1938 was only $666,602, or 6 percent. While personalty declined from 12 percent of the tax base in 1929 to about 5 percent from 1935 to date, and while corporation property increased from 15 percent in 1929 to 20 percent in the last 5 years, real estate has consistently formed 73 to 76 percent of the total base during the entire decade. Whether such remarkable uniformity of ratio, or such stability of the assessed values of property, is in accord with actual conditions over this period is not for this report to discuss. It is quite possible that in this county, as in some others, assessed values are a better index of revenue needs than of the actual "market" value of the property assessed.

Table 14.- Changes in assessed values, 1929 - 1938, Jackson County, Oklahoma[1]

Year	Real estate		Personalty		Corporation		Total
	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total	Amount
	Dollars		Dollars		Dollars		Dollars
1929	12,641,795	73	2,057,699	12	2,713,760	15	17,413,254
1930	12,747,950	73	1,934,320	11	2,815,476	16	17,497,746
1931	11,637,224	74	1,137,911	7	3,028,344	19	15,803,479
1932	9,288,801	74	740,640	7	2,492,971	19	12,522,412
1933	8,075,970	75	562,390	5	2,178,665	20	10,817,025
1934	8,078,151	74	592,514	5	2,208,338	21	10,879,003
1935	7,787,631	75	570,640	5	2,083,450	20	10,441,721
1936	7,797,015	75	614,728	6	2,044,200	19	10,455,943
1937	7,685,675	75	511,744	5	2,025,661	20	10,223,080
1938	7,685,089	76	547,490	5	1,917,844	19	10,150,423

[1] Data from county assessment rolls.

In Jackson County, unlike the counties heretofore discussed in this report, the system is followed of "selling" at each tax sale each tract delinquent for the taxes of the preceding year, even though the same tract already has one or more unredeemed tax certificates outstanding against it. Under this system, delinquent taxpapers can redeem any one or more of the outstanding certificates at any time. The resulting confusion of tax status prevents any classification of the properties eligible for resale on the basis of the year or years for which taxes are delinquent, without setting up a very large number of such classes. This is particularly true in Jackson County, which has not held a resale since 1927 nor a valid tax sale since 1933.

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[21] U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

Of the area acquired by Jackson County at the 1927 resale, only 86 acres remain in county title. The county holds 160 acres as a county farm; the State holds, as unleased or unsold school-lands or by foreclosure of mortgages, a total of 3,518 acres; while municipal and institutional tax-exempt properties bring the total area exempt from taxation to about 5,000 acres. This total is only 1 percent of the gross area of the county.

Because of the delinquency procedure in Jackson County, the area and valuation eligible for resale are classified in table 15 by year of tax sale and by civil townships, and in table 16 by number of annual tax certificates outstanding and by civil townships.

As of October 1938, there were 18,642 acres eligible for resale in Jackson County, an area equivalent to less than 4 percent of the gross area of the county. As is to be expected, the greater part (72 percent) of this area was derived from the last tax sale (1933), and progressively smaller amounts from each earlier sale (table 15). The cause of this condition has been discussed previously. Of more moment is the classification of the area by the number of tax certificates outstanding against it (table 16). Forty-five percent of the area and 53 percent of the value now eligible for resale are delinquent for only 1 year, that is, have only one tax certificate outstanding, and 20 percent and 17 percent of the area and value, respectively, are delinquent for only 2 years. This distribution indicates that chronic long-term delinquency in Jackson County is relatively light, since only 6,633 acres, or 1.3 percent of the county, have three or more annual certificates accrued against them. It must be remembered, however, that up to November 1938 no tax sale had been held since 1933, and that the presumption is great that most of these properties are also delinquent for the taxes of 1933 to 1937. If so, they would now have the taxes, due and accrued, together with penalties and costs, not of 1 to 6 years, but of 5 to 11. This fact, however, does not nullify the relatively small extent of even such long-term default.

Geographically, nearly 49 percent of the delinquent area lies in the three civil townships bordering on the Red River (Carmel, Eldorado, Elmer). In these townships, much of the delinquency is on tracts now in the river through flood-washing or ruined by depositions of sand and gravel. The remainder of the delinquency in the county presumably is related to locally poor soils, or to flood damage (chiefly through deposition) by the North Fork and Salt Fork of the Red River.

The assessed value as of 1938 of the 18,642 acres eligible for resale is $153,357. The current value is used because the values as of individual years of delinquency of each tract would have no significance under the delinquency procedure used in this county, for reasons previously discussed. This value is only 1.5 percent of the total tax base for 1938, and 2 percent of the total real-estate value. Hence, even if all of these properties, failing to attract private purchasers at the 1939 resale, should be bought

Table 15.- Area and assessed value[1] of land eligible for resale, as of April 1938, classified according to year of tax sale, Jackson County, Oklahoma[2]

Civil townships	1933		1932		1931		1930		1929		1928		Total	
	Area	Value	Area	Value	Area	Value	Area	Value	Area	Value	Area	Value	Area	Value
	Acres	$	Acres	$	Acres	$	Acres	$	Acres	$	Acres	$	Acres	$
Baucum	2,718	[3]39,095	160	2,195	0	0	0	0	0	0	0	0	2,878	[3]41,290
Carmel	1,099	3,320	200	465	640	2,445	160	455	0	0	0	0	2,099	6,685
Duke	1,348	10,425	644	5,315	80	400	0	0	160	1,460	0	0	2,232	17,600
Eldorado	3,767	26,236	578	2,095	320	3,350	320	3,205	2	30	40	180	5,027	35,096
Elmer	1,301	9,305	432	3,585	160	200	0	0	0	0	0	0	1,893	13,090
Headrick	165	500	228	2,350	0	0	160	2,360	75	500	0	0	628	5,710
Martha	945	12,495	135	975	2	215	82	851	0	0	5	190	1,170	14,726
Navajo	1,203	6,755	150	835	148	790	116	640	0	0	0	0	1,617	9,020
Olustee	658	7,930	400	1,870	0	0	40	340	0	0	0	0	1,098	10,140
County	13,204	[3]116,061	2,927	19,685	1,350	7,400	878	7,851	237	1,990	45	370	18,642	[3]153,357

1/ Value as of 1938.

2/ Data from county tax rolls and "Sale records." Tax sale is held 1 year subsequent to year of levy.

3/ Value data lacking on 150 acres.

Table 16.- Area and assessed value[1] of land eligible for resale, classified according to number of tax certificates outstanding in October 1938, Jackson County, Oklahoma[2]

Civil townships	6		5		4		3		2		1		Totals	
	Area	Value	Area	Value	Area	Value	Area	Value	Area	Value	Area	Value	Area	Value
	Acres	$	Acres	$	Acres	$	Acres	$	Acres	$	Acres	$	Acres	$
Baucum	0	0	0	0	98	2,325	245	3,675	617	10,565	1,918	[3] 24,725	2,878	[3] 41,290
Carmel	0	0	200	490	98	325	200	680	681	2,060	920	3,130	2,099	6,685
Duke	0	0	140	980	80	285	84	770	400	2,615	1,528	12,950	2,232	17,600
Eldorado	0	0	638	4,150	902	7,380	1,278	8,229	1,276	6,672	933	8,665	5,027	35,096
Elmer	0	0	0	0	160	1,255	435	1,600	320	2,010	978	8,225	1,893	13,090
Headrick	0	0	119	375	46	125	0	0	68	200	395	5,010	628	5,710
Martha	40	1,740	40	170	0	0	406	3,740	15	415	669	8,661	1,170	14,726
Navajo	80	60	396	2,650	176	365	212	705	108	715	645	4,525	1,617	9,020
Olustee	0	0	0	0	400	3,715	160	1,155	200	1,040	338	4,230	1,098	10,140
County	120	1,800	1,533	8,815	1,960	15,775	3,020	20,554	3,685	26,292	8,324	[3] 80,121	18,642	[3] 153,357
Percent of total	1	1	8	5	10	10	16	14	20	17	45	53	100	100

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[1] Value as of 1938

[2] Data from county tax rolls and "Sale records." Number of certificates is equivalent to number of years of outstanding delinquent taxes.

[3] Data lacking on 150 acres.

by the county, the loss in taxable value thereby created would not affect seriously county or district revenues. Since the average (unweighted) countywide tax rate for 1938 of Jackson County and its 26 school districts is 31.699 mills per dollar, the loss in tax revenue so resulting would be in the vicinity of $4,900, or a fraction of 1 percent of the total annual receipts of the county.

From all these data, it is evident that delinquency conditions in Jackson County are not serious, or, on the majority of properties, of long standing. Had tax sales been held annually and resales at least biennially, it is very probable that the area now eligible for resale would be much less than it is.

Love County

Love County lies in the Southern Cross Timbers of south-central Oklahoma, in the Red River Valley (fig. 1). The topography is level to gently rolling, except for (a) the sand-hills in the "neck" bounded by the horse-shoe bend of the Red River, and (b) the deeply cut valleys of Hickory Creek in the northeast part of the county and of Simon Creek in the central part. The county is served by a through line of the Gulf, Colorado, and Sante Fe Railroad, by U. S. Highway #77, and by county roads. The "black waxy soil" area, a prairie lying just north of the "neck," and the alluvial soils along the Red River are high-quality crop land, but the sandy soils of much of the remainder of the county are suitable only for range and forests. Cattle raising is an important activity, while the principal crops are cotton, corn, and sorghums. About 40 percent of the county is forest land, chiefly in the sand hills in the south and southwest, along the stream valleys, and along the edge of the Cainer Hills to the north. The chief species are scrub hickory and blackjack, post, and southern red oaks. Little or none of the timber is of commercial value except for fuel wood or posts.

The county, whose gross area is 328,960 acres, is one of the smaller counties of the State. In 1930 there was a population of 9,639, or 19 persons per square mile. The population living in the four incorporated towns in the county was 2,740, or 28 percent of the total. In 1934, although there were 244,449 acres (74 percent of the county) in farms, only 96,228 acres were in cultivation, while 74,150 acres were in pasture other than woodland pasture, and 67,230 acres were in farm woodlands.[22/]

Love County's tax base shows a sharp decline from 1928 to 1932, very similar to that in Jackson County, and a relative stability since then. The total decline from 1928 to 1938 was $2,538,600, or 31 percent, but the decline from 1932 to date was only $589,655, or 12 percent (table 17). The three elements of the tax base (real, personal, and corporation property) show remarkably uniform ratios to the total annual values throughout the decade. As in Jackson County, such uniformity in assessment may not correspond with the actual values; indeed such uniformity during the past decade is immediately suspect as "roll copying."

22/ U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

Table 17.- Changes in assessed values, 1928 - 1938, Love County, Oklahoma1/

Year	Real estate		Personalty		Corporation property		Total	
	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total	Amount	Percent of total
	Dollars		Dollars		Dollars		Dollars	
1928	2/	-	2/	-	2,008,806	29	6,719,956	100
1930	3,866,513	60	641,247	9	1,982,236	31	6,489,996	100
1931	3,430,146	56	558,310	10	2,090,017	34	6,078,473	100
1932	2,810,184	59	350,346	7	1,610,481	34	4,771,011	100
1933	2,704,202	61	289,637	7	1,426,558	32	4,429,397	100
1934	2,682,277	61	320,216	7	1,425,829	32	4,428,322	100
1935	2,532,084	60	352,360	8	1,345,641	32	4,230,085	100
1936	2,530,361	60	383,279	9	1,283,186	31	4,196,826	100
1937	2,532,009	59	443,823	11	1,293,233	30	4,269,065	100
1938	2,534,093	60	396,043	10	1,251,220	30	4,181,356	100

1/ Data are from county assessment rolls for all years except 1928; data for 1928 are from Report of State Auditor for fiscal year ending June 30, 1928.
2/ Separate values of real and personal property are not available. The total ($4,711,150) is 71 percent of the total of all property.

Love County follows the same delinquency procedure as does Jackson County, selling each tract delinquent for taxes for any one year at the next year's tax sale, irrespective of the number of other certificates already outstanding against it. The last resale in Love County was held in April 1931. Since that date, tax sales have been held in November 1931, 1932, 1933, and 1936, and, subsequent to this study, in 1938. Data were obtained on lands bid in by the county at each of these tax sales (except 1938), including the date of all certificates outstanding against each tract. As a result of (1) the extremely complex ownership pattern, very similar to that in Adair County (and arising from the same cause), (2) the large number of small tracts (10 acres and less), (3) incomplete and inexact assessment and tax rolls, and (4) failure on the part of county treasurers to keep any complete records of tax sales, determination of the tax status or even of the assessed value of each tract of rural land was extremely difficult and in some cases quite impossible. By allowing not only redemption of any certificate at any time, but subsequent sale and subdivision of such partially "redeemed" property, the legal tax status—indeed, the ownership—of lands so treated becomes a question for the courts to determine. The data in tables 18, 19, and 20 are the most accurate that could be obtained from the records found in Love County.

As of October 1938, there were 47,132 acres eligible for resale, which appeared of record on the 1938 assessment roll, and on which the county's tax lien covered full interest (table 18). In addition, there were 945 acres eligible for resale in full interest which were not assessed at all on the 1938 assessment roll, and which were not exempt Indian allotments or other tax-exempt properties (table 20). How many more acres, not eligible for resale, were likewise "off the roll" from this cause is not known. The total area eligible for resale in full interest was 48,077 acres, equivalent to 15 percent of the gross area of the county. In addition, the county held tax liens covering fractional interests on a gross area of 1,106 acres, of which 270 acres were not of record on the 1938 assessment roll (tables 19 and 20). The total area involved in delinquency, therefore, is 49,183 acres. There is no land in county title from the 1931 or earlier resales.

Table 18.- Area and assessed value[1] of land eligible for resale as of April 1938 on which county lien covers full interest, Love County, Oklahoma[2]

Years of delinquency	Burney Township		Hickory Township		Washington Township		Total	
	Area	Value	Area	Value	Area	Value	Area	Value
	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars
1935 only	8,886	50,620	6,036	32,862	2,345	19,233	17,267	102,715
1935;1932	661	3,456	1,221	7,667	869	5,653	2,751	16,776
1935;1932-1931	2,364	13,963	2,196	10,947	1,701	12,340	6,234	37,250
1935;1932-1931-1930	6,939	39,289	5,197	29,668	1,876	15,005	14,012	83,962
Subtotal	18,850	107,328	14,623	81,144	6,791	52,231	40,264	240,703
1932 only	410	1,832	147	870	980	5,992	1,537	8,694
1932-1931	40	206	90	416	200	1,552	330	2,174
1932-1931-1930	589	2,410	220	1,292	220	1,431	1,029	5,133
Subtotal	1,039	4,448	457	2,578	1,400	8,975	2,896	16,001
1931 only	1,516	7,936	810	3,896	799	5,238	3,125	17,070
1931-1930	20	100	65	506	20	160	105	766
Subtotal	1,536	8,036	875	4,402	819	5,398	3,230	17,836
1930 only	164	852	570	3,626	8	38	742	4,516
Total	21,589	120,664	16,525	91,750	9,018	66,642	47,132	279,056

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[1] As of 1938. These properties are those appearing of record on the 1938 assessment roll. See table 20 for remainder.

[2] Data are from tax rolls; no "Sale record" is kept in Love County.

Table 19.- Area and assessed value[1] of land eligible for resale as of April 1938, on which county lien covers only fractional interest, Love County, Oklahoma[2]

Years of delinquency	Burney Township		Hickory Township		Washington Township		Total	
	Area	Value	Area	Value	Area	Value	Area	Value
	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars
1935 only	140	280	110	220	30	30	280	530
1935;1932	–	–	50	100	--	–	50	100
1935;1932-1931	90	90	40	64	120	240	250	394
1935;1932-1931-1930	176	629	40	53	40	90	256	772
Total[3]	406	999	240	437	190	360	836	1,796

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[1] As of 1938, of fractional interest only.
[2] Data from county tax rolls.
[3] Since there are no fractional interests involved in delinquency in the earlier tax sales (for 1932, 1931, and 1930 taxes), this total, from the 1936 tax sale of 1935 and earlier taxes, is also the grand total of the county.

Data are not available on the area of exempt Indian allotments in the county, but many of the original grants have been alienated to white ownership and hence are taxable; probably not over 5,000 acres are still exempt. At Lake Murray State Park in northeast Love County, the State owns about 6,000 acres.

Of the 48,077 acres eligible for resale in full interest (whether assessed or not), 23,163 acres (48 percent) have but one certificate outstanding against them, that is, they are delinquent for 1935, or 1932, or 1931, or 1930 taxes only; 3,446 acres (7 percent) have two certificates; 7,292 acres (15 percent) have three certificates; and the remainder, 14,176 acres (30 percent) have four certificates out against them (tables 18 and 20). Of the 1,106 acres on which the county lien covers only fractional interest, 36 percent have one certificate out, 5 percent have two, 36 percent have three, and 23 percent have four certificates (tables 19 and 20). It is logical that the area delinquent for only one year's taxes should be the largest, since, under the procedure followed in this county, the one year may be any of the four years in which the tax sales have been held since the last resale. Why the remainder of the area, however, should follow the peculiar distribution noted is not clear, nor can an explanation be deduced from the available data. Obviously it cannot be attributed to any economic factors related to any specific year or years, since, as indicated in tables 18 and 20, the total area having two or three certificates outstanding was delinquent for various combinations of calendar years. The failure to hold tax sales in 1934 and 1935 may have been a factor, however, since it obscures the trend in delinquency throughout the past half-decade. Had sales been held, this trend might show a more logical progression, as in other counties.

Table 20.- Area of land eligible for resale not assessed on 1938 assessment roll, Love County, Oklahoma[1]

Years of delinquency	Burney Township	Hickory Township	Washington Township	Total
	Acres			
	County lien covers full interest			
1935 only	110	12	35	157
1935;1932	0	0	0	0
1935;1932-1931	0	0	19	19
1935;1932-1931-1930	44	120	0	164
Subtotal	154	132	54	340
1932 only	0	0	0	0
1932-1931	0	250	0	250
1932-1931-1930	10	0	0	10
Subtotal	10	250	0	260
1931 only	0	0	130	130
1931-1930	0	10	0	10
Subtotal	0	10	130	140
1930 only	30	5	170	205
Total	194	397	354	945
	County lien covers only fractional interest			
1935 only	0	0	120	120
1935;1932	0	0	0	0
1935;1932-1931	0	150	0	150
1935;1932-1931-1930	0	0	0	0
Total	0	150	120	270

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[1] Data from county tax roll. These properties do not appear of record on 1938 assessment roll, and hence are escaping taxation. They are not Indian lands, according to the county plat book.

Geographically, 45 percent of the "full interest" delinquency is in Burney Township, comprising the western half of the county, 35 percent in Hickory Township, the northeast fifth, and 20 percent in Washington Township, the remaining three-tenths of the county. The smaller amount of delinquency in Washington Township is occasioned by the fact that the better soils of the "black waxy" type are located almost entirely within it. Most of the delinquency here and in Burney Township is in the sand hills along the Red River.

It is estimated that about 40 percent of the total delinquent area, or approximately 19,200 acres, is forest land. This area lies mostly in the sand hills of Washington and Burney Townships, and on the edge of the Cainer Hills along the Carter County line. Most of the delinquent forest area appears to be in non-farm ownership, since it is located in non-farming parts of the county. The fact that only 15 percent of the forest area of the county is eligible for resale is difficult to explain, in view of the generally poor quality and small size of the timber. Further analysis of causes of delinquency would be necessary to explain this condition—an analysis impossible on the basis of data now available.

One further point in respect to the future trends in the tax status and economy of Love County needs emphasis. It is estimated that if and when the large Denison Dam is built on the Red River, a few miles below (southeast of) the eastern boundary of Love County, it will impound a lake sufficient to cover nearly 35 percent of the county, including much of the better agricultural land. In view of the extent of the delinquency in the remainder of this county and the present straitened finances of the local government, it appears that this development would lead ultimately to the abolishment of Love and Marshall Counties as individual entities and to a corresponding realignment of county lines. This reorganization is more readily attainable here than in some other counties, since Love County and its school districts, operating largely on a "pay-as-you-go" policy, have a low bonded debt, none of which is in default of either principal or interest payments. The straitened finances mentioned above represent only the county's inability to provide adequate public services with its available revenue; its officers are to be commended for their restraint in not bonding the county to provide them.

Carter County

A cursory survey was made in Carter County, which is just north of Love County (fig. 1). This county lies partly in the Western Cross Timbers, partly in the Central Prairies, and partly in the Southern Cross Timbers. The Cross Timbers are rolling to hilly, while the Central Prairies are level to gently rolling. Cattle, cotton, corn, and sorghums are the principal products. About half the county is forest land.

The gross area of the county is 531,840 acres, and its 1930 population was 41,419, or 50 persons per square mile. More than half the population (21,950 persons) lived in the five incorporated towns. Ardmore, the county seat and the metropolis of south-central Oklahoma, had a population in 1930 of 15,744.

Carter County has held no resale since 1931, but held tax sales annually until 1936. It follows the "endorsement" method of handling subsequent delinquent taxes.

It is the opinion of the county treasurer that 10 to 12 percent of the gross area of the county, or 53,000 to 64,000 acres, is now eligible for resale and will be offered next April. This area compares favorably with the 15 percent of the gross area eligible for resale in Love County. No estimate was obtained of the portion of this area which is forest land, but it is believed that 40 to 50 percent of the delinquent area is forested.

SUMMARY AND ANALYSIS OF FINDINGS

This report has set forth the Oklahoma law governing the procedure in the enforcement of tax collection through sale and resale of delinquent property; has discussed the variation among counties in the interpretation of statutes and in the procedure followed, with particular reference to two contrasting systems of handling taxes that become delinquent subsequent to issuance of an original tax certificate; and has shown the extent of, and trends in tax delinquency which has reached the point of forfeiture to county title, or which is now eligible for forfeiture, in eight counties in six of the major physiographic regions of the State.

The extent of the area now involved in chronic delinquency in each county is shown in table 21. The degree of delinquency—of land in county title or merely eligible for resale—in any one county depends on the date of the last resale in reference to the time of survey. Latimer County is the only one which has held a resale since 1931, and is the only county in which all the area involved in chronic delinquency is in county ownership. The area in county title in the other counties was derived from resales of 1931 or earlier years. The area eligible for resale (column 4) in April 1938 (or subsequently) is that on which tax certificates are outstanding and unredeemed for the taxes of 1935 (or earlier years), including the gross areas on which the county lien covers only fractional interest; while the 15,066 acres eligible for resale except for technical defect (column 5) is land which, although delinquent for at least 2½ years, cannot be sold in 1938 or 1939 because of procedural defects in the original tax sale. The most accurate measure, therefore, of the relative amount of long-term delinquency among the counties is the "total area involved in delinquency" (column 6), and the ratio (column 7) of this total delinquent area to the gross area of the county.

On the basis just described, the Eastern Cross Timbers, as represented by Creek County, has the greatest extent of delinquency (30 percent), followed closely, however, by the upland hardwood area of northeast Oklahoma. as represented by Adair County (27 percent). Delinquency conditions in southeast Oklahoma (Kiamichi Plateau), as represented by Latimer County; in south-central Oklahoma (the Southern Cross Timbers), as represented by Love and Carter Counties; and in the High Plains, as represented by Beaver County, appear to be very similar (10 to 15 percent). Southwest Oklahoma (the Rolling Prairie), as represented by Tillman and Jackson Counties, has much less delinquency than any other region; indeed, in Tillman County, delinquency is practically non-existent.

No attempt was made to determine accurately the causes of chronic delinquency in any county, but certain indicated relations of cause and effect have been set forth in the discussion of each county. No State-wide trend toward one specific cause is observable, however, the extent of delinquency appearing to be determined largely by local conditions.

No relation, likewise, appears to exist between extent of delinquency and the two methods of handling subsequently accruing delinquent taxes (i.e., the "endorsement" versus the "annual tax sale" method). In counties which use the endorsement method, delinquency ranges from 10 to 30 percent; in the other sample counties—Tillman, Jackson, and Love—delinquency ranges from a small fraction of 1 percent to 15 percent. This lack of distinct relationship between methodology and extent of delinquency, however, does not make State-wide uniformity of procedure in handling tax delinquency less desirable.

Table 21.- Summary of extent and status of delinquency in sample Oklahoma counties, 1938[1]

(1) Counties	(2) Gross area [2]	(3) Area in county title [3]	(4) Area eligible for resale [4]	(5) Area eligible except for technical defect [5]	(6) Total area[6] involved in delinquency	(7) Ratio of total to gross area [7]
	Acres					Percent
Latimer	470,400	63,030	0	0	63,030	13
Adair	373,760	0	100,804	0	100,804	27
Creek	616,680	6,067	168,777	7,256	182,100	30
Beaver	1,160,320	240	111,494	7,810	119,544	10
Tillman	553,600	175	0	0	175	[8]
Jackson	497,920	0	18,642	0	18,642	4
Love	328,960	0	49,176	0	49,176	15
Carter	531,840	0	[9]58,000	0	[9]58,000	11
Total	4,533,480	69,512	506,893	15,066	591,471	13

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[1] Data from county tax rolls and "Sale records."

[2] U. S. Bureau of the Census. Census of Agriculture: 1935. Washington. 1937.

[3] Acquired at resales, exclusive of land purchased and operated for governmental purposes. Includes gross area of land in which county owns only fractional interest.

[4] As of 1938 or 1939. Includes gross area of land on which county lien covers only fractional interest.

[5] Owing to technical procedural defects, this land, while otherwise eligible for resale in 1938 or 1939, cannot be sold.

[6] Sum of columns (3), (4), and (5).

[7] Column (6) divided by (2), expressed in percent.

[8] Less than 0.5 percent.

[9] Estimated.

If these eight counties constitute a representative sample of the 77 counties of Oklahoma in respect to delinquency conditions (and it is believed that they do), the data indicate that 13 percent of the gross area of the State, an area of more than 5-3/4 million acres, is involved in long-term tax delinquency. In certain parts of the State, chronic delinquency is not serious, but in others it has reached alarming proportions. In these latter areas, the situation calls for prompt remedial action, involving substantial modification of present policies and practices with respect to disposition and utilization of delinquent land. While specific remedies for specific areas will require additional local studies, the present investigation has indicated certain broad approaches and recommendations which, it is believed, will prove efficacious in the State as a whole. These will be set forth briefly.

RECOMMENDATIONS

One of the outstanding defects in the present administration of tax-collection enforcement in Oklahoma is the excessive latitude allowed the counties in the method of holding tax sales and resales. As already has been pointed out, the officials of each county do about as they please, not only as to holding or not holding tax sales and resales, but also as to the method of handling delinquent taxes at such sales. There need be no doubt as to the value of State-wide uniformity in date and method of tax sales and resales; surely such was the legislative intent of the present statutes, and it is clear that any system that permits local autonomy in such matters violates the principles of State sovereignty and of the equality of all taxpayers of the State before the law. A uniform method of handling taxes becoming delinquent on a property already covered by an outstanding tax certificate should be set forth clearly either by amending the statutes, if necessary, or by strictly enforced regulations from the State Examiner's Office, so that one system or the other is mandatory in every county in the State, under penalty for non-compliance. In the writer's opinion, which is shared by most county officials and by the Assistant Attorney-General, the "endorsement method" conforms more closely to the legislative intent and to sound fiscal practice.

The present statutes state that the tax sale and the resale "shall" be held annually. As has been shown, this provision is currently a dead letter. It is extremely doubtful that any county in Oklahoma has consistently complied with this statute. The chief argument used to justify non-compliance is that the costs of such sales (particularly of resales) exceeds the returns. If this be true, it may be desirable to revise the method of sale to reduce the cost. The State Government itself has abetted—indeed, compelled—non-compliance in certain years, by executive order or legislative enactment. This may have been justified during the emergencies of the depression or of natural catastrophes such as the dust storms of recent years, but, in providing a justification for local non-compliance in other years, it has set a bad example. The requirement of an annual sale should hereafter be strictly enforced.

As a corollary to these first two recommendations, and as the most effective way of enforcing local compliance, it is recommended that tax title be forfeited to the State rather than to the county. Most States take title to tax-forfeited lands, compensating the county for its share of tax money when the property is sold by the State. It is recommended that the procedure now required by statute in Oklahoma be followed through resale, but that all land bought by the county at resale be deeded forthwith to the State, the county to be recompensed to such extent as may be deemed equitable, either from the sale price of the property when it is sold by the State, or from the proceeds accruing to the State from the property when it is used for public benefit. Since such lands as would go to the State under this procedure have been subject to redemption for $2\frac{1}{2}$ years subsequent to tax sale and have been offered at public resale, and since for another year the public's title is subject to suit to invalidate it on grounds of technical procedural defects, neither the original owner nor the county can claim justly that their respective rights will be jeopardized by deeding the property to the State.

To carry the process further, in order to insure the utilization of such lands in accordance with the best use to which they are suited and to protect the public interests and rights in the State's basic natural resources—soil, water, timber, minerals—it is further recommended that, immediately subsequent to vesting of tax title in the State, the land be classified as to its adaptability for public or private use by an official agency representing both State and local experts in land-use classification. Land classified as "private" should then be made available for sale to the highest bidder, the county receiving such portion of the sale price as may be deemed equitable. Land classified as "public" should be held by the State, and administered, developed, and maintained by that division of the State government given statutory jurisdiction over the particular use to which the property is to be devoted. In this case, the county would receive a portion of the gross annual proceeds derived by the State from the sale of products from, and leasing of rights on, the land.

It is obvious that a solution must be found to the problem of reimbursing the counties for the loss of their equity in tax-forfeited lands deeded to the State—a solution that will be equitable as between the individual county and the State. Possibly one method of solving this problem would be to provide for the payment by the State to the County of a flat percentage (25, 40, or 50 percent) of the sale price (if and when the property is sold by the State), or of the gross annual proceeds (if the property be held and developed by the State). Such a system, however, is open to two rather serious objections; (1) the amount of the payments under this provision might in time be out of proportion to the equity of the county as well as to the net income derived by the State; (2) determination of the amount of these payments might require rather elaborate bookkeeping where tax-forfeited lands were consolidated with interlocking tracts of purchased lands not subject to a similar provision.

A possible solution to these objections may be found in provisions (1) limiting the total amount payable to a county to the amount of its claim on account of all delinquent taxes, penalties, and costs; and (2) making the proceeds due the county determinable by any reasonable method of allocating income (on an acreage, or value, or other basis) from the different tracts of an operating unit where tax-forfeited lands were intermingled with other lands in such unit. Such details can be worked out by the interested agencies and political divisions of the State Government.

Specific provisions for inclusion in a statute to effect these general recommendations have already been submitted to interested agencies of the State Government and to the Codification Committee of the State Bar Association; they are now being drafted into a measure for consideration by the next Legislature.

Two minor recommendations, the basis for which has been previously discussed, are also made. Immediately upon "sale" of land or other real estate to the county at the first tax sale subsequent to original delinquency, the assessed value of the property should be stricken from the county assessment roll, and should not be restored thereto until the property is again subject to taxation. This will prevent the building up of purely fictitious assessed values in the county and prevent the issuing of excessive bonds and warrants based on such "watered" values.

The State School-Land Commission, if it is to continue making loans to farmers out of State school-land funds, should compensate the counties for the delinquent taxes accrued on land on which the Commission forecloses its mortgage. At present, all back taxes are forever lost to the county, unless the Commission should, by chance, resell the land to the original mortgagee—a rare occurrence. The uncertain taxable status of these lands—vacillating between tax-exempt, State and taxable, privately leased—now prevents the counties having large areas in this category from stabilizing tax revenues and frequently results, particularly in years of local economic stress, in a considerable actual loss of anticipated taxes.

These recommendations are not set forth as a panacea for all the fiscal, administrative, economic, or social ills involved in the problem of long-term tax delinquency in the eight counties covered by the present study, much less in Oklahoma. If adopted, however, they would make Oklahoma eligible for Federal grants under the Fulmer Act. They are believed to be sound from both the fiscal and economic standpoints; and they are calculated to point the way toward a solution of many of the maladjustments in land use and fiscal administration now reflected in the excessive long-term tax delinquency found in most sections of the State.

OCCASIONAL PAPER NO. 81 MARCH 7, 1939

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IMPROVEMENT CUTTINGS IN SHORTLEAF AND LOBLOLLY PINE

by

R. R. Reynolds, Associate Forest Economist,
Southern Forest Experiment Station

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IMPROVEMENT CUTTINGS IN SHORTLEAF AND LOBLOLLY PINE[1/]

by R. R. Reynolds,
Associate Forest Economist,
Southern Forest Experiment Station

It is not unusual to see identical twin boys or girls, but have you ever seen identical twin trees: two that are growing at the same rate, have the same size and length of crown, contain the same volume, have the same number of limbs of the same size and kind, and possess knots of the same size in identically the same places? Furthermore, have you ever seen two lumber or pulp-mill operations that were identical: two that cut the same kind and size of trees, use the same logging equipment, have the same woods and mill production costs, manufacture the same products in the same manner, and follow the same utilization practice?

I have never seen two identical trees. Neither have I seen two identical mills. Because of this wide variation in tree form and because of the great number of controlling physical and economic factors, the practice of forestry will always remain at least 50 percent art and not over 50 percent science. It is also because of this difference in trees, timberland owners, sawmills, and utilization practices that I can give you no last and final word on stand-improvement cutting methods and practices. The practice that will work well on one acre, or on one section, of one company's holdings may not work at all in another locality. I am firmly convinced that in each case details regarding cutting have to be worked out on the ground. But I can and will tell you the reasons I think improvement cuttings are desirable, how they best can be made, and the results that we have obtained from such cuttings.

During the past several years at Crossett, Ark., the Southern Forest Experiment Station has been working on selective-logging studies, pulpwood production-cost studies, and improvement-cutting studies, all in second-growth timber. Based upon the general results of these studies, I am of the firm opinion that timber growing in the future holds as much, or more, promise of profit as did the purchase and sawmilling of virgin timber in the past. But one of the first measures required of forest owners who wish a good net income from their forest holdings, is to get the "weeds" out of their crop. All stands of timber, regardless of whether virgin, old-field, or second-growth, contain a certain number of "weed" trees that should be removed in order to make room for good crop trees. In many stands, 25 to 75 percent of the ground area is occupied by such trees. I am sure most owners do not realize that in the shortleaf-loblolly pine type a stand or growing stock, equivalent to about 1,100 board feet per acre is necessary to produce sufficient growth to pay expenses. Therefore, if a timberland owner has 100,000 acres of timber that contains a large proportion of "weed trees," with a growing stock of only 1,100 feet of merchantable timber per acre, his only compensation is the fun of handling this property without paying anything for his pleasure. If, however, he disposes of the worthless and low value trees and builds up the growing stock, for example, to 5,000 board feet of high-quality trees per acre, then he may have to worry about spending an annual income of $150,000 per year. There is no magic needed to make money in timber growing. In fact, it needs nothing more than a bit of good, uncommon sense along with a little capital.

[1/] Presented before the Gulf States Section of the Society of American Foresters meeting in New Orleans, La., Nov. 5, 1937.

The success in improving stands by cutting depends upon the knowledge and skill of the owner, or manager, in determining which trees to cut and which to reserve for future growth. It must be realized, of course, that no hard and fast rules for marking can be set up, and that on a particular property the decisions as to which trees to cut must be made on the ground. A good rule to follow, unless economic necessity requires a heavier cut, is to mark only those trees that either are "financially mature" or are interfering with the growth and development of more valuable individual trees. Many people think that financially mature trees are only large mature ones, but in reality, financially mature trees may be of nearly any size and age—from 2 to 40 inches in diameter and from 10 to 300 years of age. A financially mature tree is one that because of location (perhaps under a large overtopping tree), or because of rot, crook, limbiness, or age, is either decreasing in value each year, or is not growing in volume or quality at a rate sufficient to produce a net return above the yearly cost of carrying this tree in the stand. We may list among these financially mature trees:

1. Badly suppressed trees, which are certain to go out of the stand within the next 5 years through natural mortality.

2. Trees that because of the crooked condition of the bole, will never produce saw timber. Fast-growing, crooked trees that contain, or will contain, pulpwood, should be left for additional growth if they do not interfere with the development of more valuable trees.

3. Trees that show unmistakable evidence of red-heart or other tree-destroying fungi.

4. Trees that contain fire scars or other injuries sufficiently severe to make them susceptible to wind damage.

5. Extremely brushy or limby trees that will never produce lumber of average quality better than grade #2C, and that will become less valuable for pulpwood or cordwood as more limbs develop.

6. Limby trees that will never produce at least one #2 sawlog should be removed if they interfere with more valuable trees.

After determining which trees are "weeds," the next problem is to get rid of them. Should we attempt to girdle them all, cut all of them for pulpwood and fuel wood, or cut only those that will "pay their way" and leave or girdle the others? With new markets developing, e.g., for pulpwood, a "high, wide, and handsome" girdling operation can hardly be recommended. On the other hand, cutting of pulpwood or fuel wood at a loss cannot be justified. Every effort should be made to find profitable markets for pulpwood, fuel wood, chemical wood, ties, posts, bolts for box boards and handle stock, or for any other of a possible 100 products; and then only those trees should be cut that will yield a profit.

We have made large-scale improvement-cutting studies on the Crossett Experimental Forest in the shortleaf-loblolly pine type to determine if such improvement cuttings can be made without cost. We have kept accurate cost records of the cutting on about 400 acres of second-growth timberland and also on enough trees of the various species to determine what type of tree cannot be cut at a profit into any salable product. We first cut the pines on the various areas and determined the cost and profit, and then from the same areas cut the hardwoods.

The defective or low-quality pine was cut into pulpwood at the following cost per 144 cubic feet:

Marking cost, including paint, etc.	$.035
Oil, wedges, saws, saw-filing, etc.	.115
Labor	1.030
Total	$1.180

The value in the woods on part of the wood produced on this cutting was $1.50 per 144 cubic feet, and on this unit we made a net profit of $.32. When the study was about half completed, the value of the wood increased to $2.00 per unit f.o.b. the woods; therefore, on about half the material we made a net profit of $.82 per unit. We obtained an average of 1.35 units of pulpwood per acre from this cutting, or a net income of $1.11 per acre with pulpwood at $2.00 per unit. It's not bad to have someone pay you for letting him pull the weeds out of your corn patch, is it?

After cutting the low-grade pine from the area we made an improvement cutting of the hardwood portion of the stand and sold the material for chemical wood. The cost of this cutting per 138 cubic feet was as follows:

Marking cost, including paint, etc.	$.035
Oil, wedges, saws, saw-filing, etc.	.115
Labor	1.590
Total	$1.740

The value in the woods of most of the chemical wood we have produced has been $2.00 per 138 cubic feet; therefore, our profit on this unit has been $.26. Of course we were fortunate in having a chemical-wood market that others might not have. Other markets, however, were available for this material; in fact, we developed a wood market that became so good that we could not fill the demand. A market is also available for low-grade hardwood logs to be cut into ties, timbers, and lumber. We thus had several chances to sell most of this low-grade material. As mentioned before, we made a study of the cost of production for all sizes and classes of trees, and as soon as we had determined definitely that we were losing more money on certain trees than it cost to girdle them, we quit cutting them.

Except for the large and extremely rough trees with large branches clear to the ground, from some of which it was practically impossible to split the bolts, we made a profit on all pines 4 inches d.b.h. and larger that had at least two sticks of pulpwood. In the hardwood portion of the stand, however, we had no market for red and black gum of low quality. We also lost money on large and very rough oak of several species and on most of the large hickory. Furthermore, it was generally not profitable to cut hardwoods below 7 inches d.b.h. into either chemical wood or fuel wood. On the remainder of the hardwoods we made a reasonable profit.

What disposal can be made of the red and black gum and the extremely rough and limby pines and hardwoods remains a problem. Since a market for both red and black gum for pulpwood, posts, and piling promises to develop in the near future, it seems desirable to save these trees until the market develops or until we are sure that a market will not be available. If we save the gums, we then have per acre only about 2 financially mature trees out of the 10 to 20 with which we started. It is often suggested that timberland is cheap and that instead of girdling large wolf trees we should let them stand and buy more land. In some cases this may be a good practice, but each "wolf" tree may occupy one-tenth of an acre of ground, and girdling usually costs less than 5 cents a tree. If an acre were fully occupied with such trees, it would thus cost a maximum of 50 cents an acre to girdle. Where can other land be bought for 50 cents an acre?

It is not always necessary or advisable to carry on the improvement cutting entirely separate from other types of cutting. If this work is to be done under contract, it is much simpler to have it follow immediately a sawlog or other cutting and to have both operations done by the same contractor. By handling both cuts, the contractor not only can add a few butt logs from the cull trees to his sawlog operation, but he also can add the topwood from sawtimber trees to the pulpwood, chemical wood, or other products removed during the improvement cutting.

In conclusion, it may be stated that our studies of improvement cuttings in both pines and hardwoods indicate that such cuts are immediately profitable, and furthermore that they leave the stands in such a condition that they will later produce a greater volume of a higher quality and value. Our results also have been substantiated by several large companies that have followed similar practices in strictly commercial operations on very large areas.

Note: Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Projects 701-3-9 and 365-64-3-7.

OCCASIONAL PAPER NO. 82 MAY 16, 1939

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

WHAT ARE WE GOING TO DO WITH OUR HARDWOODS?

by

I. F. Eldredge, Regional Director,
Forest Survey of the South

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people,and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

WHAT ARE WE GOING TO DO WITH OUR HARDWOODS? [1]

by
I. F. Eldredge, Regional Director,
Forest Survey of the South

In discussions up until now of the South's forest resources, your attention has been directed frequently to the pines. To me, one of the most interesting facts developed by the Federal Forest Survey is that in both area and volume there is more hardwood timber in the lower South than there is pine. This is an unexpected finding. Most of us have been brought up to picture the lower South as a pine country—the home of the greatest pine forest in the world. The recent development of the kraft paper industry in the South has accentuated the emphasis on our pine forests, and even those of us who had a first-hand acquaintance with southern forests failed to realize the true situation. As a matter of fact, the Forest Survey found on the 122 million acres of forest land in the eight states of the lower South (fig. 1) that 51 percent of the area is occupied by hardwood forest types, either pure or mixed with pine, and that of the total volume of usable wood material, amounting to 1,449,000,000 cords, hardwood trees contain 63 percent. Strictly speaking, cypress is not a hardwood, but in this discussion I have included it with the hardwoods.

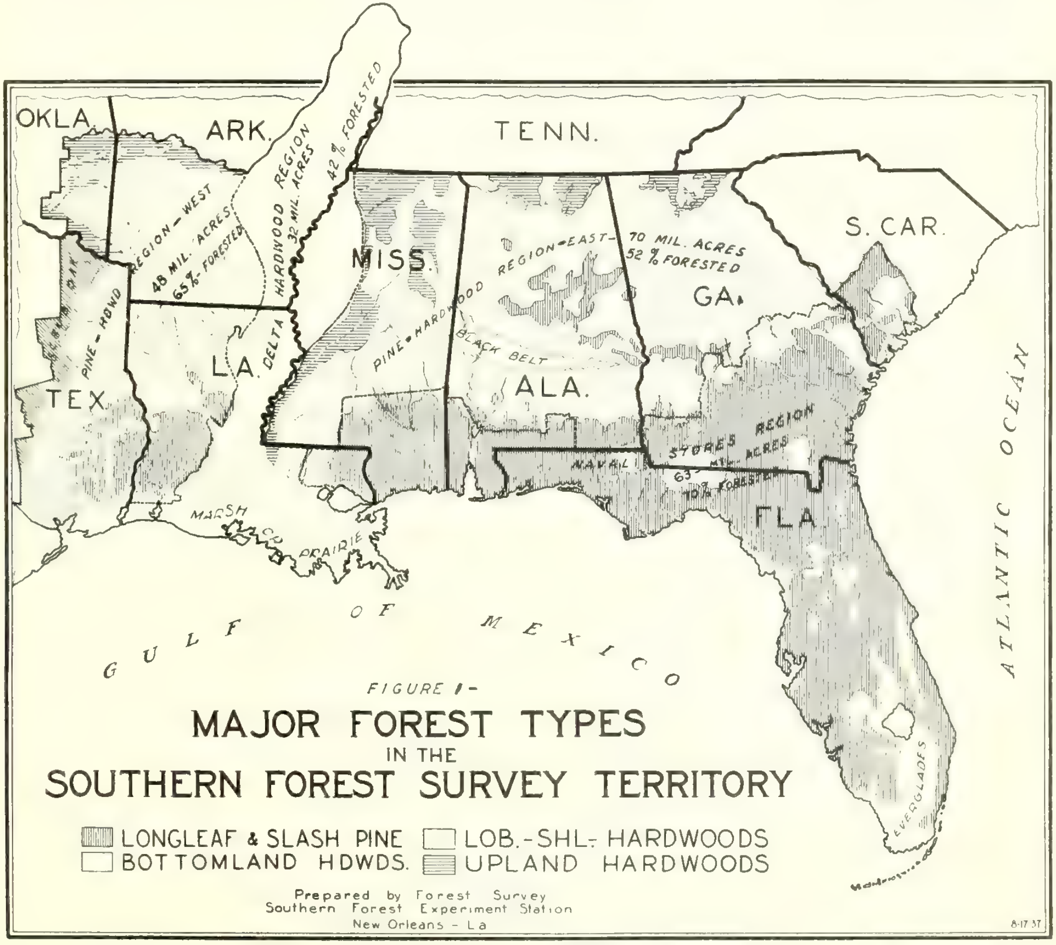

FIGURE 1 – MAJOR FOREST TYPES IN THE SOUTHERN FOREST SURVEY TERRITORY

Prepared by Forest Survey
Southern Forest Experiment Station
New Orleans – La

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[1] Address presented before the Southern Pulp and Paper Club at the Paper Festival Savannah, Ga., April 18, 1939.

It is my purpose briefly to discuss the hardwood-supply situation and its significance in the development of forest industries in the lower South. First, let us look at a map showing the territory covered by the Forest Survey. As may be seen, it includes the entire area of Georgia, Florida, Alabama, Mississippi, and Louisiana, the commercial forest regions of Texas and Oklahoma, and about three-fourths of Arkansas. Small portions of the Mississippi delta in Missouri, Kentucky, and Tennessee are also included. For the purpose of exposition and discussion, the territory has been divided into four forest regions, as follows:

1. The Naval Stores Region, an area of 58 million acres lying along the South Atlantic and Gulf Coast, approximately 71 percent of which is forested. The characteristic forest species are longleaf and slash pines, but many other species of both pines and hardwoods are associated with them.

2. The Pine-Hardwood-East Region, lying east of the bluffs of the Mississippi delta country and north of the naval stores belt. This region which contains 70 million acres of land surface and is 52 percent forested, is a pine-hardwood country, with loblolly and shortleaf pine as the characteristic conifers in admixture with southern hardwoods.

3. The Delta Region, which supports an almost pure stand of bottomland hardwoods and extends in the flood plain of the Mississippi River from Cairo at the junction of the Ohio and the Mississippi southward to the Gulf of Mexico. It contains a gross area of 32 million acres, of which 42 percent is forested.

4. The Pine-Hardwood-West Region, extending westward from the Mississippi delta to the plains and the scrub oak forests of Texas and Oklahoma. Its forests are primarily mixtures of pines and southern hardwoods, with longleaf, loblolly, and shortleaf pines as the characteristic conifers. It contains a gross area of 48 million acres, of which 65 percent is forested.

It is interesting to note that the 122 million acres of forest lands make up nearly 58 percent of the total land area of the lower South. This great forest is predominantly composed of young stands that have come in since the liquidation of the original forests; 77 percent of the forest area is classified as second growth. The original old-growth stands, some of which have been culled over, occupy only 15 percent of the forest area; and 8 percent of the area, while still forest land, is stripped of its forest cover.

FIG. 2-FOREST AREA CLASSIFIED ACCORDING TO FOREST TYPES

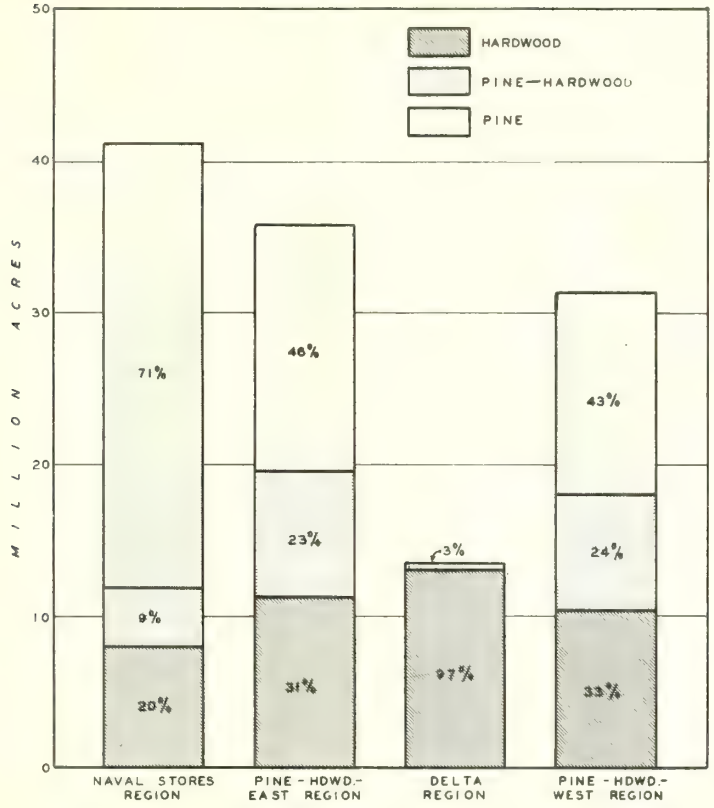
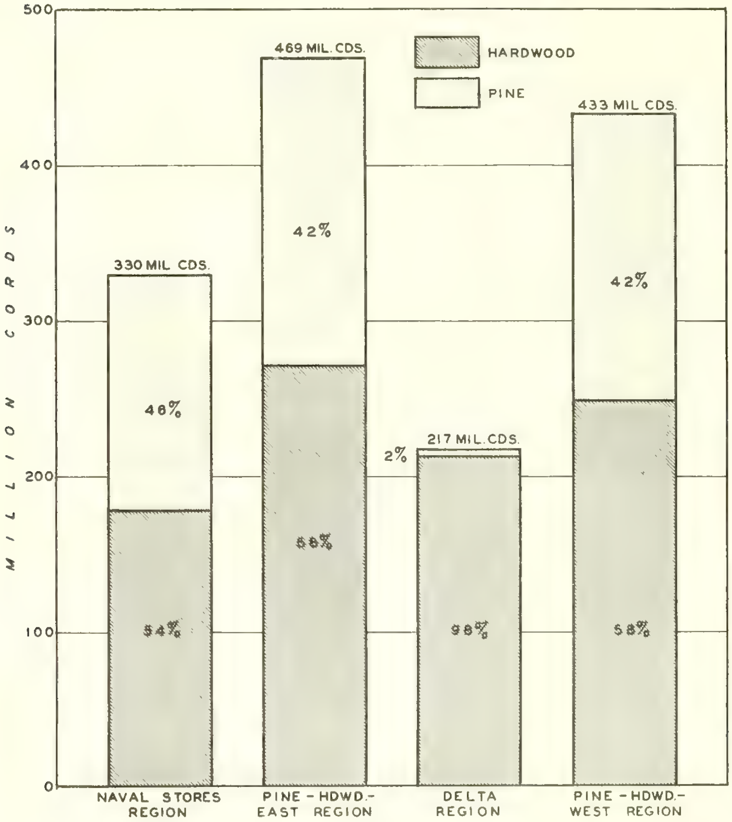


Figure 2 shows the classification of the forest area according to dominant forest types that characterize each of the four forest regions of the lower South. As may be seen from this chart, the areas occupied by pure hardwood and mixed pine and hardwood forest types make up 29 percent of the forest land in the Naval Stores Region, 54 percent in the Pine-Hardwood-East Region, 100 percent in the Delta Region, and 57 percent in the Pine-Hardwood-West Region. The two hardwood types occupy 51 percent of the entire forest region of the lower South.

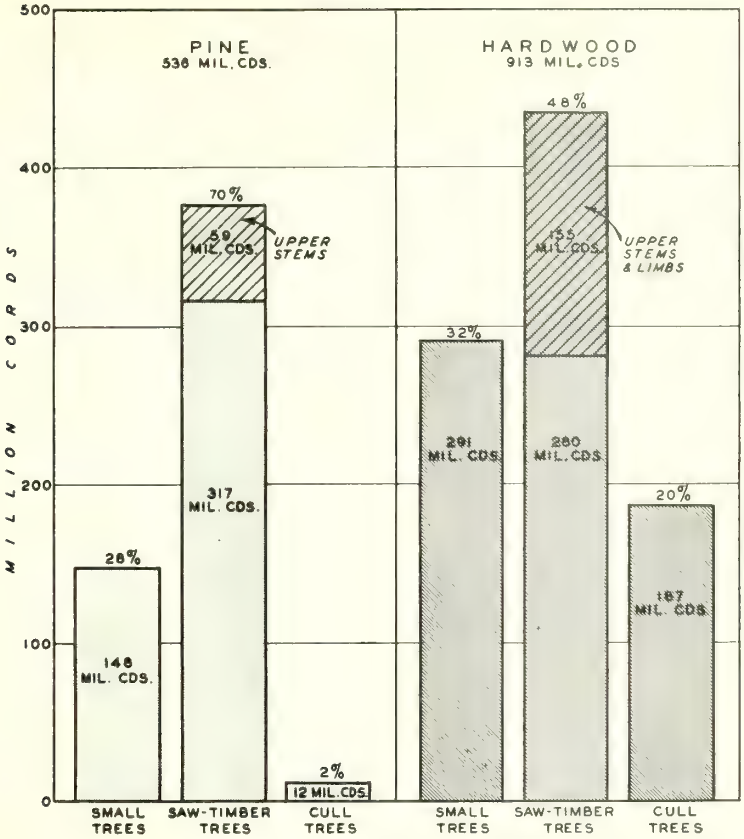
FIG. 3 – TOTAL VOLUME OF USABLE MATERIAL
INCLUDES SOUND & CULL TREES 5 INCHES & LARGER



The total volume of usable material in standing timber in the lower South is estimated by the Survey to be 1,449,000,000 cords. This volume includes the usable contents of all trees 5 inches d.b.h. and larger, including cull trees. The hardwood species contain 63 percent of the total usable volume. As indicated in figure 3, hardwoods make up 54 percent of the volume in the Naval Stores Region, 58 percent in the Pine-Hardwood-East Region, 98 percent in the Delta, and 58 percent in the Pine-Hardwood-West Region. The Pine-Hardwood-East Region contains the greatest quantity of wood volume, all species combined, and the greatest volume of hardwoods. It is interesting to note that the volume of hardwoods in the Mississippi Delta Region, which has long been famous for its great hardwood forests is exceeded by that in each of two other regions in the lower South.

Let us examine this timber volume from the standpoint of the size- or quality-classes into which it falls. As shown in figure 4, the Survey found the total pine volume to be 536 million cords. Of this, 28 percent is in small trees—trees in the 6 and 8 inch d.b.h.-classes. Generally, these trees are considered too small for lumber production. Seventy percent of the volume, including both lower and upper stems, is in saw-timber trees, i.e., trees 10 inches d.b.h. and larger. Cull trees, unfit for many industrial uses, contain 2 percent of the volume.

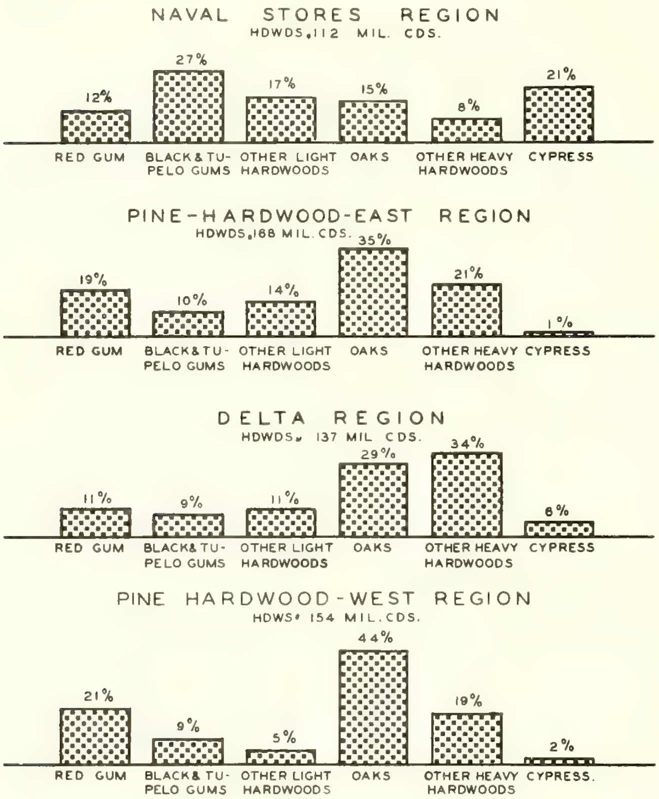
FIG. 4 – TOTAL VOLUME OF USABLE MATERIAL



There are 913 million cords of hardwood, of which 32 percent is in small trees (5 to 13 inches d.b.h.), 48 percent in saw-timber trees (14 inches d.b.h. and larger) with upper stems and limbs included, and 20 percent in cull trees unfit for lumber, veneer, and many other industrial uses. It should be noted that of the 913 million cords of hardwood there are 633 million cords in small trees, cull trees, and the upper stems and limbs of saw-timber trees. For this tremendous volume of wood there is at this time little or no industrial demand. Of course, a very considerable number of the small trees must be allowed to grow in order to perpetuate the forest stands and provide future hardwood timber.

The same hardwood species are found generally throughout the lower South but they occur in varying proportions in the four sub-regions. Figure 5 gives a cross-section of the hardwood growing stock in the several regions. As used here, "growing stock" does not include the volume in cull trees or in the tops and limbs of saw-timber trees; only sound trees are included. In the Naval Stores Region, the so-called light hardwoods, or woods generally considered as of pulping quality, make up (cypress included) 77 percent of the 112 million cords in the hardwood growing stock. The paper maker, however, is commencing to look upon the oaks and the other heavy hardwoods as potential sources of pulp. I have seen samples of good white paper made from overcup oak and from water hickory or bitter pecan.

FIG. 5 - PROPORTION OF VOLUME IN SPECIES-GROUPS IN HARDWOOD GROWING STOCK

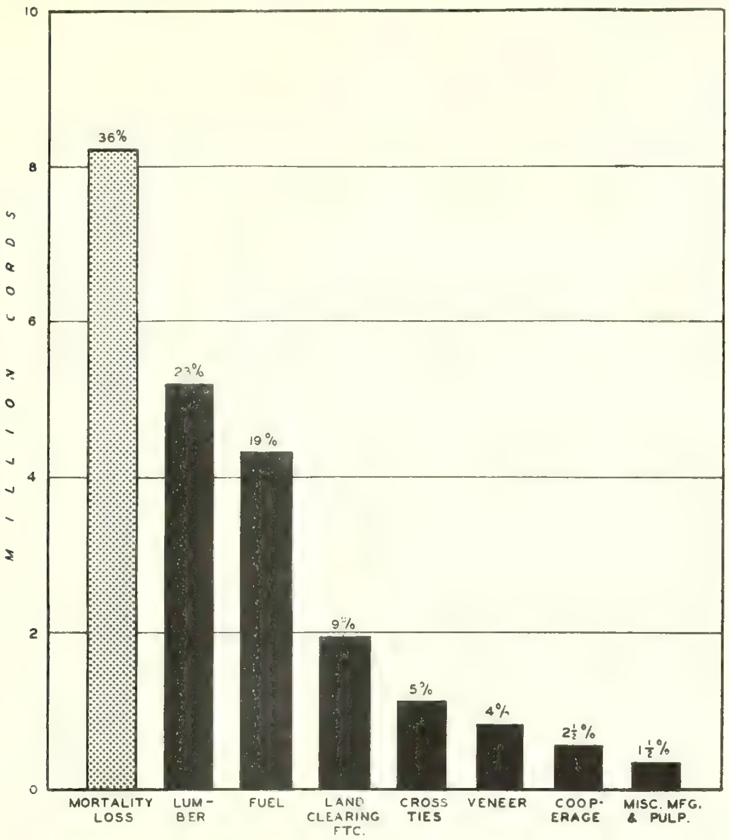


In the Pine-Hardwood-East Region, red gum, black gum, tupelo, and other light hardwoods, including cypress, make up 44 percent of the hardwood growing stock. In the Delta Region, the pulping hardwoods (cypress included) make up only 37 percent, and in the Pine-Hardwood-West Region, the pulping hardwoods with cypress also include 37 percent of the volume in the hardwood growing stock.

The lumberman of today treats a number of the hardwood species common to the lower South with some indifference. Several of the oaks and hickories, and a number of other species among both the light and heavy hardwoods, find no appreciable demand in the lumber market and perforce are left to stand as inferior species awaiting the development of new uses.

So far we have considered only the extent and volume of the forest resource of the lower South. In order to better understand the situation, however, it is necessary to consider the drain against this resource. From figure 6 we see that in 1936 the total drain against the hardwood growing stock from all causes and for all uses was 22½ million cords.

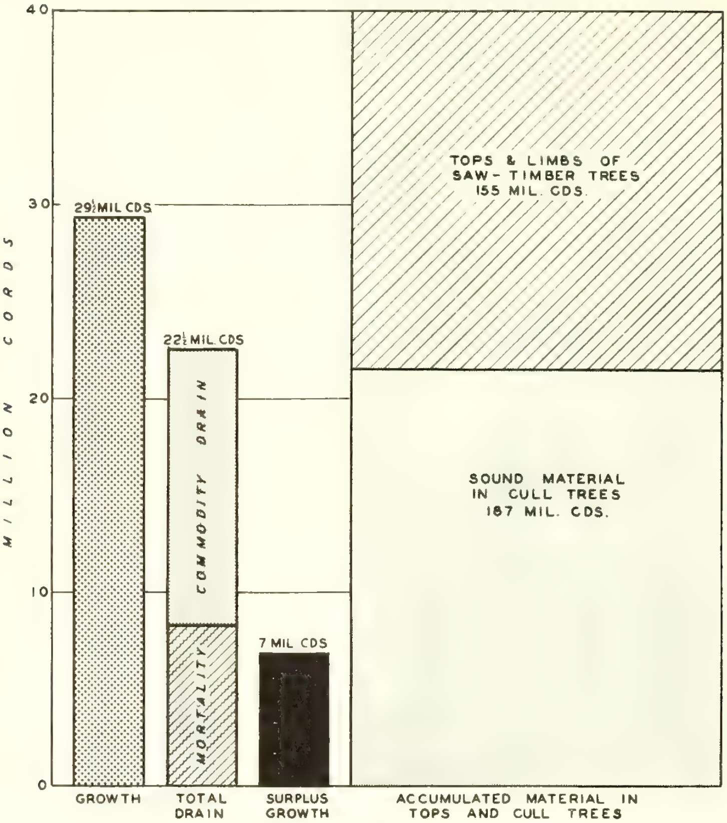
FIG. 6 - THE DRAIN AGAINST THE HARDWOODS, 1936.



By far the greatest source of drain, amounting to 36 percent of the total, was the loss due to mortality, a profitless consumption if there ever was one. The production of lumber caused 23 percent of the drain; fuel wood, 19 percent; land clearing and other farm use, 9 percent; cross ties, 5 percent; veneer, 4 percent; cooperage, 2½ percent; and all other uses, including pulpwood, 1½ percent. The mortality loss is primarily due to fire, insects, disease, wind-storms, and to over-crowding in dense young stands. A great part of it is preventable, and to the extent that better protection and wiser management reduces this annual loss, to that extent the sustained money-yielding possibilities of the region can be increased.

How does this drain compare with the current annual growth of the hardwood growing stock? In 1936, the sound-tree growing stock, no cull trees included, increased through growth to the extent of 29½ million cords. This growth exceeded mortality losses plus commodity drain by 7 million cords. Figure 7 shows the comparison of growth and drain, and in addition shows, on a comparable scale, the accumulated volume of material now to be found in cull trees and the tops and limbs of saw-timber trees and usable for pulpwood, fuel wood, chemical conversion, etc. It should be understood that the volume found in this category is not current production; it is the accumulation of years. Its removal from the forest would be of great benefit to the remaining stands, and its conversion into dollar returns on investment, into opportunity for labor, and in tonnage for transportation would be of tremendous benefit to the country as a whole and to the lower South in particular.

FIG. 7—COMPARISON OF CURRENT GROWTH
OF THE HARDWOOD GROWING STOCK
& TOTAL DRAIN 1936
WITH ACCUMULATED MATERIAL IN TOPS & CULL TREES



The big question is: "What can be done with this huge volume of hardwood?" The industrial hardwood-lumber business requires in the main a high proportion of fine-quality hardwood, such as is seldom found in either young or small trees. Until this industry changes its requirements and takes the species now considered as inferior and uses young trees of comparatively small size, it cannot be expected to use any very large part of the current annual increment, or any part at all of the accumulated volume of cull trees and the tops and limbs of saw-timber trees. The veneer and cooperage industries also require trees of higher than average quality, and are limited, in the case of cooperage at least, to a comparatively few of the many hardwood species. The pile and pole industry, at best, uses only trees that meet certain specifications as to form and quality and cannot be expected to use any part of the accumulated cull material. The railroad-tie industry uses a considerable amount of hardwood, but it is not likely to increase greatly its demand in the future.

All of the present day uses combined are not reducing appreciably the tremendous accumulation of sound usable material now in cull trees and in the tops and limbs of saw-timber trees amounting to 342 million cords, nor are they adjusted to the utilization of the saplings and small trees now needing removal from over-crowded stands. In addition to this mass of material, there is at the present time an annual increase in the growing stock of sound trees, over and above all drain, amounting to 7 million cords of wood.

Obviously, a new deal is needed for our hardwoods. The chemists and industrial engineers, particularly paper chemists, should take this huge mass of cheap raw material fully into account and consider ways and means of converting it into goods for the domestic and foreign markets.

On millions of acres throughout the region tributary to existing pulp mills, the hardwoods and the pines are mixed. As long as we pulp only the pine component of these stands, we are practicing both poor economy and poor forestry. A pulp mill almost anywhere in the lower South would have to buy perhaps only half the acreage of land that it buys for pine alone if it were to use the hardwoods with the pines. To put it another way, the average haul in the lifetime of a pulp mill would be cut in half if the hardwoods as well as the pines were taken to the mill. It is inevitable that southern hardwoods will eventually find their way to the pulp mill, but the industrial chemist will not consider hardwoods for paper pulp alone--the field is wide open for synthetic board, plastics, and the production of basic chemicals, textiles, and maybe even food. Our industrialists, the most progressive in the world today, have in our southern hardwoods a new, intriguing, and almost unlimited field for the exercise of that bold initiative, keen inventive genius, and facility for organized salesmanship that is their American heritage. In the technological development of its hardwoods, the South may take another step forward, and a long one too, in its program of balancing agriculture with industry.

Note: Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Projects 701-3-9 and 365-64-3-7.

OCCASIONAL PAPER NO. 83 MAY 20, 1939

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

FORESTS IN THE ECONOMY OF THE SOUTH

by

I. F. Eldredge, Regional Director,
Forest Survey of the South

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FORESTS IN THE ECONOMY OF THE SOUTH [1]

by
I. F. Eldredge, Regional Director,
Forest Survey of the South

Once again the South is suffering from a maladjustment in its agricultural economy. Millions of acres of former cotton fields have been thrown out of cultivation and a considerable part of its population is suffering because of lack of opportunity for gainful employment. Its railroads, its power companies, and its ports have all been affected adversely, and the tax bases of its cities, counties, and States have been weakened. The Nation and the South itself is feeling the blight of its lessened purchasing power.

Everywhere in the South its leaders have come to believe that the most hopeful remedy for a distressing situation lies in an expansion of industries, particularly manufacturing. Every part of the South is taking stock of its resources and facilities with a view toward bidding for factories (with payrolls and with raw-material requirements) that will furnish dependable, profitable, nearby markets for its labor and produce.

It can be understood, therefore, how gratefully the recent spectacular expansion of the pulp and paper industry in the South has been received. In the last 4 years or so, 15 new plants have been (or are being) built south of the Potomac River, representing an investment of around $100,000,000 of new capital in plants alone, to say nothing of additional millions invested in tributary forest land. This is a big step in the direction the South wants to take.

This development, as much as anything else, has directed attention to one of the South's chief assets—its forest resource. It is my purpose in this brief article to give a view of the salient facts concerning the amount, character, and capacity of the timber resource of that part of the South embraced in the eight States, or parts of States, lying west of the Savannah River and including Georgia, Florida, Alabama, Mississippi, Louisiana, the eastern timber belt of Texas, about three-fourths of Arkansas, and the extreme southeast corner of Oklahoma. This area, which is shown on the accompanying map (fig. 1), for convenience is hereafter designated "the lower South."

The data presented here were gathered by the Forest Survey of the South, which, as an activity of the Southern Forest Experiment Station, has been making a field inventory of the forest growing stock, and concurrently, a detailed canvass of the forest-using industries. This work has been under way since 1932, and to date over 40 resource reports have been made available for public use.

The over-all land area of the region covered is, in round figures, 213 million acres. Of this area, the Survey determined that 122 million acres, or nearly 58 percent, can be classified as productive forest land. The areas characterized by certain dominant forest type-groups are shown on the accompanying map. The Survey found that, for the lower South as a whole, old-growth forest stands occupy only 15 percent of the forest area; second-growth stands of sawlog size occupy 38 percent; second-growth stands under sawlog size, 34 percent; seedling areas, 5 percent; and clear-cut land, i.e., land from which the timber crop has been totally removed and no new crop has taken its place, 8 percent.

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[1] This paper was prepared for inclusion in the souvenir program of the Annual Southern Paper Festival, Savannah, Ga., April 17-19, 1939.

On this land the timber cruisers found the huge volume of 255 billion board feet of timber in sound trees of sawlog size. The total growing stock of the lower South, including not only trees of sawlog size, but all sound trees 5 inches d.b.h. and larger, and expressed in standard cords (4 x 4 x 8 ft.), stacked with the bark on, totaled the sizable sum of more than one billion cords, of which 525 million cords are pine. In the accompanying tabulation (table 1) is a statement of the forest area and the volume of the growing stock by States, expressed in cords. It should be observed that the volume in the hardwood species makes up more than half the total volume of growing stock.

Table 1. - Forest area and volume of growing stock[1] by States

State	Total productive forest area	Net cordwood volume of growing stock		Total
		Pine	Hardwood and cypress	
	Thousand acres	- - - - - - Thousand cords[2]	- - - - - -	
Texas[3]	10,553	67,348	52,324	119,672
Oklahoma[3]	2,961	8,028	8,696	16,724
Arkansas[3]	14,820	65,214	99,287	164,501
Louisiana	16,194	53,033	115,651	168,684
Mississippi	15,869	57,015	91,552	148,567
Alabama	18,860	91,449	75,960	167,409
Georgia[4]	21,036	122,959	79,197	202,156
Florida[5]	21,653	59,776	48,353	108,129
Total	121,946	524,822	571,020	1,095,842

[1] Includes all sound trees 5.0 inches d.b.h. and larger. The upper stems to a 4-inch minimum are included for all sizes of pine, for hardwoods 5.0 to 12.9 inches d.b.h., and cypress 5.0 to 8.9 inches.

[2] Stacked standard cords (4 x 4 x 8 ft.) including bark.

[3] Includes only that part of the State in the forest region of the lower South. The south Missouri delta is included with Arkansas.

[4] Excludes the Okefenokee Swamp and Coastal Islands, which have an estimated productive forest acreage of 299,000 acres.

[5] Excludes the Ocala National Forest and the Everglades, which have an estimated productive forest acreage of 224,000 acres.

In the long run, and if the South's development is to be based soundly, the forest-using industries must keep at least within the productive capacity of the forest growing stock. We have not always done this, and in the past many of our communities and the region as a whole have suffered because of short-sighted liquidation

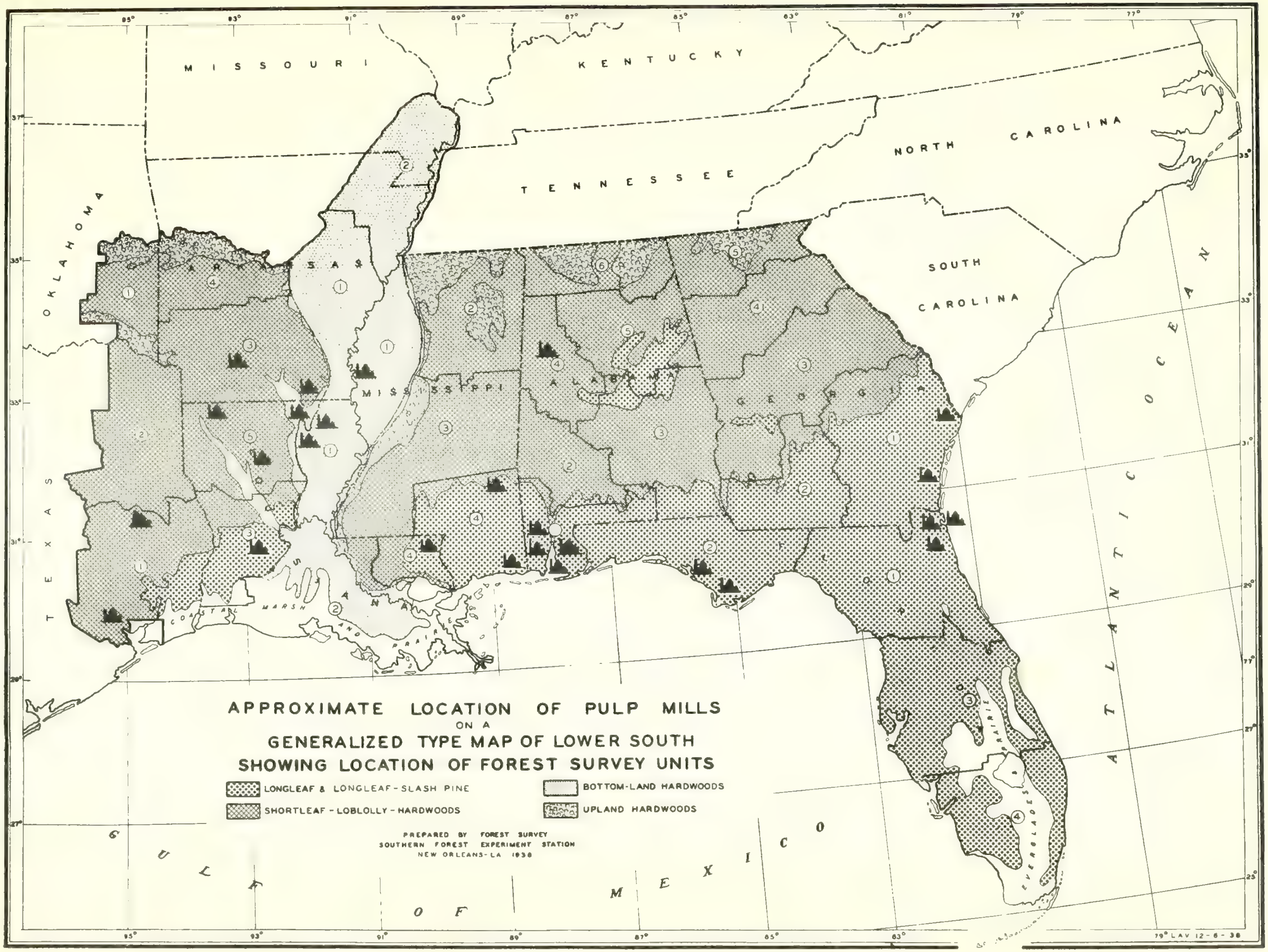
APPROXIMATE LOCATION OF PULP MILLS ON A GENERALIZED TYPE MAP OF LOWER SOUTH SHOWING LOCATION OF FOREST SURVEY UNITS

FIGURE 1.

The present measure of the extent to which we may safely dip into our forest wealth is its annual increment, that is to say, the net amount of wood produced annually through growth. Mortality is deducted in computing the increment, and the volume of wood in cull trees, dead trees, and the tops and limbs of sawlog-size hardwoods and cypress is not taken into account in either growing stock, increment, or drain.

The current annual increment of the forests of the lower South for the year 1936 is shown by States and species-groups in figure 2. For the region as a whole, based on a rough conversion from increment calculated in cubic feet, it totals nearly 48 million cords, 56 percent of which was contributed by pines.

As stated before, this annual increment is net. It is interesting to note that in 1936 the Survey estimated that the loss due to mortality amounted to about 8 million cords of pine and 8 million cords of hardwood and cypress. This annual loss is due in a large measure to the direct and indirect effects of forest fires and to the non-observance of the elementary rules of forest management. It will never be possible to eliminate entirely annual losses, but widespread and effective fire protection and rational forest management could reduce the losses tremendously and, to that extent, swell the volume of increment from which to maintain industry.

The forests of the lower South are already the source of raw material for a large and well-developed forest industry. The Survey found over 10 thousand forest-using plants of all kinds, including 8,000 sawmills, 1,100 turpentine stills, 24 pulp mills, and many other forest-products activities.

In addition to the annual drain of the forest resource of these industrial plants, it was found that the annual requirement for fuel wood, together with other domestic uses, constitutes one of the largest items the forests are called upon to furnish. The drain from all sources in 1936 amounted to almost 40 million cords, of which lumber accounted for 53 percent; fuel wood and other domestic uses, 24 percent; pulpwood, 4 percent; and all other uses, 19 percent.

The commodity drain on the sound-tree growing stock, as compared with the net increment for 1936, is also shown in fugure 2. Although a favorable balance existed that year between increment and drain, the situation is not static. It is obvious that in several States the margin is so small that existing industries responding to a boom-time demand of forest products might reverse the situation quickly and cut more than the annual increment. On the other hand, it is entirely within the power of southern timber owners to increase materially in every State in the lower South the volume and the quality of the annual increment.

In every one of the 30 Survey units it covered in the lower South, the Forest Survey found that the existing forest growing stock is from only a fourth to a half of what the forest sites are capable of sustaining. This is what might have been expected, for it must be realized that 85 percent of our forest area is second growth that has grown to its present size without the benefit of any conscious effort towards good husbandry, and exposed to the debilitating effect of oft-repeated forest fires. The forests, therefore, are characterized over many large areas by thin stands handicapped by the presence of cull trees, and in some sections by badly over-crowded young stands, in which density of stocking increases mortality and decreases increment.

TOTAL DRAIN VERSUS NET INCREMENT
ON GROWING STOCK IN STANDARD CORDS
1936

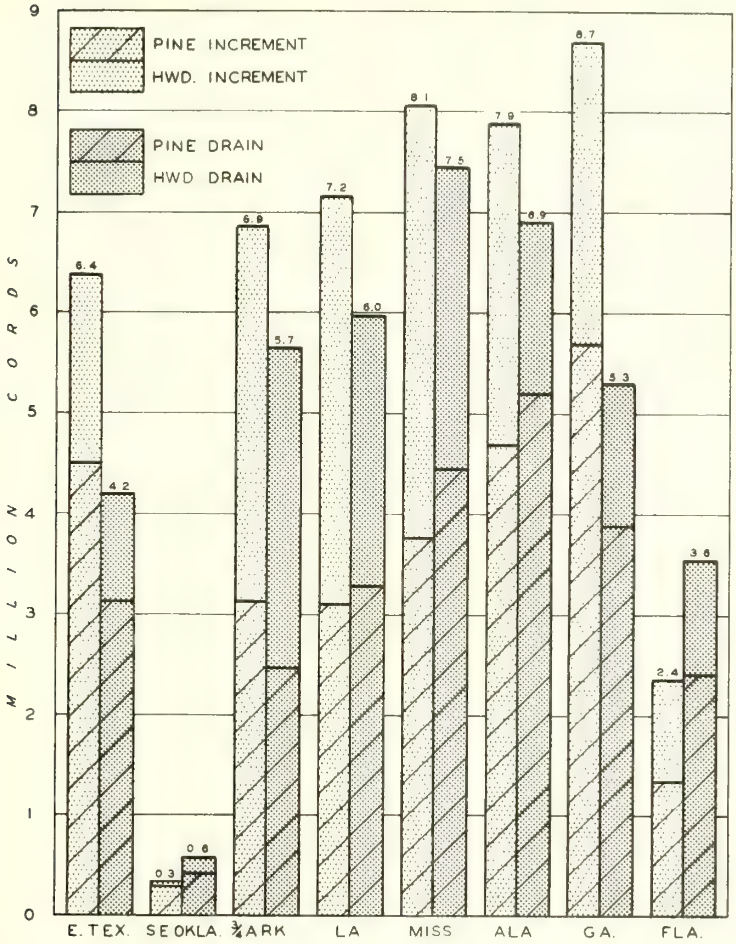

FIGURE 2.

There is a source of supply in the forests of the lower South not accounted for in the preceding statement of volume of growing stock, nor in the comparison of increment and drain. This is the sound usable volume in cull trees and parts of trees not included in the above statements. The Survey found that this volume has accumulated to the very large sum of more than 350 million cords of wood! By far the greater part of this volume is in the hardwood species-group. To the extent that this huge volume of material is used in industry or for domestic purposes, it can supplement the cut from annual increment. Its removal from the forest stands would constitute a much needed step in improving the growing conditions of the sound-tree growing stock.

On the face of it, the figures presented in the chart showing the comparison of increment and drain may be disappointing, in that they apparently do not hold much promise for the large-scale industrial expansion that the South so sorely needs. But, fortunately, this is not true; the present forest area in the lower South is capable of supporting on a sustained-yield basis a greatly expanded forest industry. It cannot do this, however, if it is treated in the future as it has been in the past. The forests of the South are, in the main, young stands that will respond promptly and satisfactorily to intelligent efforts to develop them.

There is room for more pulp mills in the South, provided that the newcomers follow the example of the mills that are already established and buy suitable forest lands in adequate acreage and put these lands under sound technical forestry management designed to produce successive crops of timber to the full capacity of which the land, the climate, and the species are capable. The 24 pulp and paper mills now established in the lower South have, through their forward-looking forestry policy, already given a marked impetus to better forest-land management in the region. Other industries depending upon the forest for their raw material must, if they expect to maintain their places in the sun, adopt similar policies.

In addition to securing the major part of their future supplies through land ownership and forest management, the forest industries in all categories will find it to their financial advantage and future security to join forces with the public agencies in preaching and practicing good forest management on the non-company lands to which they must look for a considerable part of their requirements for wood.

Eager as the South is for more forest industries, it wants only those industries that will so use the resource as to become a permanent part of its economic structure. The pulp and paper industry is looking for the promised land where it may settle down, at last, to move no more. Properly managed, protected, and utilized, the forests of the South will provide a sound basis for a secure future—an ever-continuing succession of timber crops that will be a permanent resource for a permanent industry.

Note: Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Projects 701-3-9 and 365-64-3-7.

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE TEXAS LEAF-CUTTING ANT (ATTA TEXANA BUCKLEY) AND ITS CONTROL IN THE KISATCHIE NATIONAL FOREST OF LOUISIANA

by

M. R. Smith
Bureau of Entomology and Plant Quarantine,
United States Department of Agriculture

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

THE TEXAS LEAF-CUTTING ANT (ATTA TEXANA BUCKLEY) AND ITS CONTROL IN THE KISATCHIE NATIONAL FOREST OF LOUISIANA

by
M. R. Smith,
Bureau of Entomology and Plant Quarantine,
United States Department of Agriculture [1]

Introduction

Although for a long time the Texas leaf-cutting ant has been known to defoliate plants in Texas and Louisiana (3 and 4) [2], it was not until late in 1934 that these ants were recognized by officials of the Federal Forest Service to be serious pests of young pine trees.

At the request of the Forest Service, T. E. Snyder early in 1935 made recommendations for the control of this ant on the Kisatchie National Forest in Louisiana. The results of this preliminary control work, together with data on the biology and distribution of the ant, were published in January 1937 (6). Here it was shown conclusively that the ant is a serious pest of young pines and that control operations are practicable and definitely warranted.

During the fall of 1936 and the spring of 1937, approximately 100 ant colonies on the Kisatchie Division of the Kisatchie National Forest were treated by the Forest Service with carbon bisulphide (CS_2) in a routine manner as part of a control project. Great credit should be given to P. J. Ceremello (1) for devising better technique, namely, use of a funnel and hose, during previous control operations, and to C. R. Crawford (2) for putting these control operations into effect. Special data were kept on the time of treatment, amount of chemical used, and costs. In addition, 78 colonies were treated on other Divisions of the Forest at this time, but owing to lack of time it was not possible for the writer to check or investigate the work done on these Divisions.

In the summer of 1937 (June 1 - Sept. 1), the writer carried on extensive poisoning experiments with the aim of determining whether or not the ant could be controlled by summer treatment during the period of slack work, and also to ascertain if any other chemicals were more efficient than CS_2 in the treatment of the nests; under efficiency was included their relative toxicity, cost, practicability in handling, etc.

This paper deals mainly with the results of the poisoning experiments conducted in the summer of 1937, but the writer also was able to check on the work done in the winter of 1936 and the spring of 1937 by the Forest Service. In addition valuable data were gathered during this work relative to distribution, relation to soil and vegetative types, habits of the ant, etc.

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[1] This article was prepared while the author was temporarily employed by the Federal Forest Service, under a cooperative agreement between the Southern Forest Expt. Sta. at New Orleans, La., and the Bureau of Entomology and Plant Quarantine. Under the supervision of Thomas E. Snyder of this Bureau, the author was assisted in the field work by Paul Schuler and J. R. Sonderegger, student assistants employed by the Forest Service.

[2] Italic numbers in parentheses refer to literature cited at end of this paper.

Damage

The attacks of this ant on young planted pine trees occur in the late fall, winter, and early spring when there is a dearth of other green foliage. The injury consists in the cutting off of the needles close to the bud of the seedling in longleaf pine and the cutting off of both the needles and bud, as well as girdling of the living bark, in slash pine.

The injured longleaf pines are weakened, but the damage resulting from defoliation appears not to be so severe, unless drought or other factors also affect the tree, when it may succumb, resulting in a much higher mortality than indicated at the first part of the season. In the case of slash pine, the injury results in the death of the trees. After trees have become 2 to 3 feet high, they seem to have grown beyond the stage of fatal injury. Unfortunately this damage coincides with the planting season, December to March.

Another type of injury is to longleaf pine seedlings in the cotyledon stage under conditions of natural reproduction, and here 100 percent loss has occurred in areas immediately adjacent to the ant colonies.

No accurate data on the percentage of pine trees killed by ants or the monetary loss involved are at hand; at this time so many factors are involved that not even estimates can be given. Such data would have to be accumulated on a large scale and over a number of years to obtain a fair index of the loss occasioned by ants, which are capable, however, of attacking any young pines within a radius of 300 to 400 feet of their nest.

The Ant

The ant is known to entomologists as Atta texana Buckley or the "Texas leaf-cutting ant." There are many other common names applied to this species, however, such as "night ant," "parasol ant," "pack ant," "cut ant," and "fungus ant." In Louisiana the ant is spoken of by farmers as the "red town ant" or "chisel head," the former designation being most common. It is the only ant that has a pronounced defoliating habit (in its restricted area of distribution), and in Louisiana it can be recognized by its characteristic nests, which consist usually of large, irregular, bare surfaces of soil with numerous and irregular reddish craters scattered over them. Owing to the reddish subsoil brought to the surface by the ants, the general surface of the nest usually has this characteristic color.

Distribution

The Texas leaf-cutting ant, so far as is known, is confined entirely to Louisiana and Texas, although its exact range has not yet been mapped very accurately. According to reports sent by R. R. Reppert (5), Extension Entomologist of Texas, the ant might be said to occupy approximately all of Texas (from the extreme southern boundary almost to the Oklahoma line) east of the 102° meridian and thence eastward into western Louisiana as far as the 92.5° meridian. In Louisiana, the ants are definitely known to occur in 13 parishes: Bienville, Webster, Sabine, Vernon, Beauregard, Allen, Calcasieu, Jefferson Davis, Rapides, Natchitoches, Grant, LaSalle, and Winn (see map). The record cited previously for Washington Parish is an error. This ant is not a recent introduction into Louisiana, but owing to the fact that it is found largely on nonfarming areas or waste lands, it has previously escaped much attention.

It should not be concluded from an examination of the map that the ant is continuously or uniformly present throughout its range, because it is limited by at least three distinct factors, which account for its sporadic distribution, namely, soil type, topography (including drainage), and exposure.

Within the range of distribution of Atta texana in Louisiana (see map) there are 14 types of soil, according to the Atlas of American Agriculture for 1935, published by the U. S. Department of Agriculture. A number of these, however, are unsuited for it because of their physical character and poor drainage. The ants are especially common in the lighter phases of the Susquehanna, Norfolk, Orangeburg, Cuthbert, and Ruston fine sandy loams and may occur in soils of a similar nature that contain not less than approximately 60 percent sand in the surface soil. The subsoils of these lighter phases are generally of such a nature that they cannot be compressed into definite balls by the hands as can the heavier soils. Colonies in Louisiana are always located on well-drained sites, that is, crests of ridges, promontories, or the sides of hills; they are never in low areas or in heavy or poorly drained soils. Although there are favorable soils in Louisiana outside the known area of distribution, for some reason not yet determined the ants do not occur there.

It will be seen from this that the ants show a distinct preference for sandy or sandy loam soils, but Walter (7), who made an extensive study of the ant in Texas, states that although the ants there show in most cases a preference for such soils, he has known them to live in heavy soils or in those of limestone origin. In Louisiana their distribution is almost coextensive with that of longleaf pine. In a general way it might be said that the ants live in a longleaf pine habitat in which there is a loose sandy type of soil and in which scrub oaks are also common.

There seems to be a close correlation between the location of ant colonies and exposure. A check of 38 nests showed 17 on southern slopes, 13 on western, 5 on eastern, and 3 on northern. Location of the nests on southern and western slopes would give the ants the advantages of retaining much of the accumulated daytime heat throughout the night. J. A. Hyslop, in a letter to the writer, calls attention to the fact that the ant's northern distribution may be determined by temperature: "The northern lines of known distribution of the insect coincide very nicely with the southern limit of 10° F. annual minimum temperature."

Number of Colonies per Acre

It is difficult to give very exact data on the number of ant colonies per acre. On the planted areas in the Kisatchie National Forest, there is a great amount of variation depending on soil types, exposure, drainage, vegetation types, etc. A general average based on a large number of typical planting areas in the Kisatchie National Forest shows an average of about one ant colony per 90 acres. In an area extremely ill adapted to the nesting of these ants, Crawford found only 4 colonies in 2,800 acres. From conversations with farmers living in rather favorable nesting areas for the ants, it was learned that one colony may be expected on approximately every 15 or 20 acres. Under extremely favorable conditions, however, several colonies may be separated by only a few hundred yards.

Nesting-Site Indices

One of the most important phases of control work is the locating of colonies for treatment, since it is clearly evident that untreated colonies, or parts of colonies, will be a constant source of future loss.

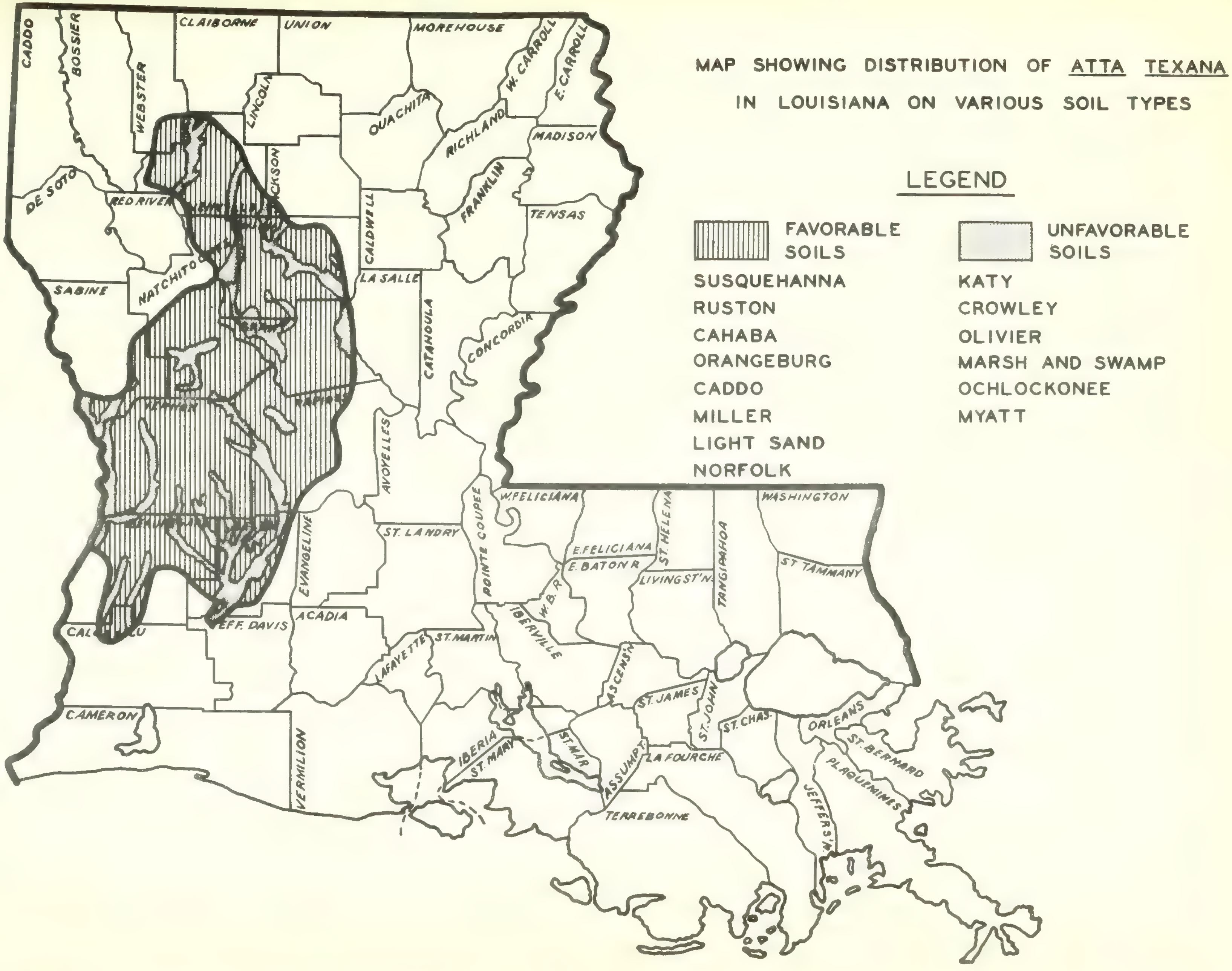
In scouting for the ants one should keep the following points in mind: (1) they prefer only sandy or sandy loam soils; (2) their nests are always located on well-drained sites such as promontories or the sides of hills; and (3) the nests are more common on western and southern exposures.

The general nest area (center of the colony) may cover from less than 100 square feet to as much as 3,000 to 5,000 square feet, depending upon the age of the colonies. The general nest area usually consists of a bare surface, which is raised several feet above the rest of the surrounding soil. As it is washed down by rains, it is constantly built up with subsoil brought up from below. In a large part of the Louisiana range of the ant, the subsoil is reddish, giving a very characteristic color to the nest area. Scattered over the general nest area will be found innumerable variously shaped mounds—crater shaped, crescent shaped, etc.—but sometimes the holes are left flush with the surface of the earth, and no soil is piled around to form distinct mounds.

If a nest is large, and consequently old, grass may be growing over parts of it, or it may have caved-in holes, some 4 square feet in area or larger; these are due to the great excavation work beneath, assisted by weathering. Around many of the older nest areas, there are dense clusters of dog fennel, Eupatorium capillifolium Small, which in some regions serves as an excellent nest-site index. Two explanations for this ring of dog fennel around the nest are: The seeds of the plant may have found the loosely pulverized soil dumped there by the ants an especially good site; or the ants in bringing seeds to their nest, as they often do, may have accidentally dropped them there. The former reason seems more plausible. Many nests are surrounded by small, rather dense growths of scrub oaks.

As one leaves the main nest area, he will observe small mounds scattered rather irregularly here and there, often far apart. The farther one gets from the nest, the less numerous are these mounds, most of which represent the lateral galleries that extend from the nest and are used as entrances and exits for the ants in their foraging expeditions. These foraging holes often can be found 300 feet or more from the nest; one measured was 317 feet from the main colony and was 18 inches to 6 feet beneath the soil. Furthermore, ants in foraging may go several hundred feet beyond the last foraging hole; ants were observed cutting leaves from a tree 480 feet distant from the colony. Most of the laterals are down slope, since the ants occupy the crests of ridges.

In summer, especially during the hot part of the day, the ants remain in their nest below the surface of the soil; hence their activity cannot be relied upon to locate the nest or to determine the size and condition of the colony. Scouting is also more difficult in summer because of the density of plant growth, which conceals the ant nests; but in winter, when the ground is rather bare and the trees and shrubs are denuded of their foliage, one can often detect an ant colony on a hillside as far away as one-fourth of a mile.



MAP SHOWING DISTRIBUTION OF ATTA TEXANA IN LOUISIANA ON VARIOUS SOIL TYPES

The Nests

The larger nests in Louisiana occupy a considerable surface area and have innumerable craterlike mounds clustered irregularly over the surface. The depth to which nests extend in the soil is amazing, namely, 10 to 20 feet. So far as is known, no other North American ant approaches this species in the depth to which it constructs its nest.

An excavated nest is found to consist of hemispherical chambers with flat floors and arched roofs. In these chambers, which are connected by galleries, the ants live, their only food being a fungus that they grow upon macerated leaves cut from vegetation.

The interconnecting galleries range in size from the width of a finger to 2 inches or more. The chambers, which are usually first encountered 2 to 3 feet below the soil surface, may extend to a depth of 15 feet. Two types of galleries lead into the main nest: those that lead almost vertically down from the nest surface above; and others, which might be termed laterals or feed holes, that have a horizontal trend and may lead 300 feet or more from the nest. The vertical galleries, which are more angular or spiral in their construction, are apparently used principally for removing excavated earth and perhaps also for ventilating. The horizontal galleries are used mainly for bringing in excised leaves.

The number of holes per ant nest, including those from both lateral and vertical galleries, is astounding. Some colonies studied had approximately a thousand, and a few exceptional ones had less than a hundred; the general average was several hundred.

Colony Activity

The activities of a colony depend largely on suitable temperatures for work. During the hotter months of the summer the ants remain quiescent during the day, but with the coming of dusk and lower temperatures they begin to forage and to excavate their nests, continuing during the night. Evidences of their night activity are the freshly excavated mounds and the bare, smooth trails leading from their forage holes to some plant that they have been defoliating. These trails may be from 1 inch to 3 or 4 inches wide, and if they did not contain particles of excised leaves, accidentally dropped by the ants, one might think they were made by a snake. In summer most of the nest holes are plugged with earth or ligneous debris. Although most of the ants are quiescent during the day, occasionally a few workers are excavating, or even foraging, but they do not wander far from the nest because of the heat of the sun.

In winter the ants forage during the day instead of at night. At temperatures between 45° and about 80° to 90° F., they are active, but they are not active on cold, wet, or cloudy days, especially in the morning.

The effect of extreme heat on the ants was well brought out by an "experiment" conducted near Provencal, La., in August 1937. Workers of different sizes were taken from an active colony and dropped on the hot sand, the temperature of which ranged from 123° to 130° F. Various workers died within 6 seconds to 1½ minutes at these temperatures, the larger ones being more resistant to the extreme heat than the smaller. After an individual had lost control of its legs and tumbled over on its back, death proceeded rapidly, and the last struggles were indicated by twitching of the antennae and legs.

Control Investigations

During the summer of 1937 various chemicals were tested as soil fumigants in an attempt to determine whether summer treatment was as effective as winter treatment, and also to ascertain whether any of these chemicals were more effective and cheaper than carbon bisulphide (CS_2). The chemicals used were CS_2, trichlorethylene, gasoline, hydrocyanic acid gas, and hydrogen sulphide. In all, 66 nests of different sizes were treated with these chemicals in varying proportions, and apparent eradication was obtained in only 3 of the 66 nests, namely, those treated with CS_2.

Thirty-eight experiments were conducted with CS_2, using it at rates varying from 3/4 pint to 25 pints per colony. Every ant hole was staked out and the chemical was then injected into some of the holes by means of a small funnel with rubber tubing attached. On the main nest, holes about every 10 feet were treated with the liquid at rates varying from $\frac{1}{4}$ pint to a pint, and holes outside the nest at from 1/8 to $\frac{1}{4}$ pint. All holes were plugged whether treated or not. In only 3 of the 38 colonies treated with CS_2 were the ants eradicated, In many the ants were reduced in numbers appreciably, but the amount of poison required, the cost, and the general results obtained showed very clearly that poisoning was not practical or effective in the summer.

Another chemical considered to be a possible substitute for CS_2 was trichlorethylene, a liquid which volatilizes on exposure to air, is heavier than air, is cheaper than CS_2, and is not inflammable or explosive at ordinary temperatures. So far as is known, this chemical has not been used previously as a soil fumigant for ants. Seven tests were conducted, using the liquid in the same manner as CS_2 and at rates varying from 2-1/8 pints to 17-5/8 pints per nest. No eradication was obtained in any of the tests, and reduction in numbers was very slight in most of the colonies treated.

Since gasoline was not expected to be an effective control for ants, only two tests were conducted. In one test 9 pints were used, and in another 12 pints. Eight holes on the main nest of each colony were treated with a pint of gasoline per hole, and the remainder injected into outside holes at rates of 1/7 to 2/5 pint per hole. Both the treated colonies were unusually small and should have been eradicated if the gasoline was at all effective, but both colonies showed scarcely any effect of the treatment.

Hydrocyanic acid gas, derived from potassium cyanide (KCN) crystal "eggs" by dissolving 1 ounce of the cyanide in a half gallon to a gallon of water, was used in 13 colonies. The solution was poured into holes on the main nest and into outside holes by means of the funnel and rubber tubing, the same as the CS_2. The heaviest dosages were injected into the holes of the main nest, while varying dosages were placed in the outside holes; 2 to 24 ounces of KCN crystals were used per colony. Not a single colony was eradicated, and the reduction of the ants in all cases was negligible. Furthermore, this chemical has many objectionable features: It forms a gas lighter than air and thus does not penetrate into the lower chambers; it requires a supply of water in the field at all times to form the gas; and it is an extremely dangerous poison to use in both solid and gaseous states.

Hydrogen sulphide gas (H_2S), although very toxic to animal life and not inflammable or explosive at temperatures above the average, is lighter than air and has a most disagreeable odor. The gas was injected into holes on the main colony with a rubber tubing which led from a tank in which it was under high compression. Since 2 to 10 ounces (and more) of the gas was used per colony without any appreciable reduction in numbers, this chemical offers no promise whatever as a cheap and effective means of controlling the ant.

CS_2 was the only chemical that showed any appreciable effectiveness, and even it did not reduce the number of the ants enough to warrant the large amount of material required or the expense entailed. Summer treatment for the ants, therefore, is not recommended under any conditions or with any chemical.

One of the main phases of investigation carried on during the summer was to check as many colonies as possible in the Kisatchie Division of the Kisatchie National Forest to determine whether the poisoning carried on there during Jan.-Mar. 1937 by C. R. Crawford had been effective in either eradicating or controlling the ants. Although approximately 100 colonies had been treated, using an average of 6.75 pints of CS_2 per colony, time permitted the writer to check but 38, which were selected at random in order to give as fair results as possible. The results of this inspection are given in table 1. Of the 38 colonies treated, 26 showed complete eradication,3/ 10 showed at least 99 percent eradication, and 1 showed nearly 95 percent; only one showed little effect of the treatment, indicating that for some unknown reason the gas did not reach the colony.

Two colonies were treated during the last of January, 26 in February, and 10 in March. Fifty percent of the colonies treated in January were eradicated, whereas 70 percent of those treated in February and March were eradicated. Walter (7), in working with the ants near San Antonio, Tex., states that he obtained the best kill with CS_2 from late February to early April; he believes the reasons for this are that the ground is then warm enough for rapid evaporation of the chemical, and the ants are more concentrated in the nest than later. He also states that in 99 nests treated between Feb. 5 and April 16, the ants were killed in 88 with the first treatment, whereas 10 required a second treatment and 1 required a third.

The colonies treated by Crawford ranged in size from $\frac{1}{4}$ acre to $1\frac{1}{2}$ acres, and the number of holes treated was 25 to 300. The cost of treating was 2 cents per hole, or approximately $2.08 per acre, including materials, labor, and transportation.

In the Kisatchie National Forest during the winter of 1936-37, 178 colonies were located and treated in fenced areas that aggregated 18,790 acres. The colonies averaged 300 holes each, 74 of which (average) were treated. To treat adequately an average colony required 7.2 pints of the chemical. The cost per hole thus averaged 3.4 cents; and the cost per acre, $3.06. The cost prorated against the entire acreage, protected as well as treated, would be 2.3 cents per acre. The average planting cost for the 1936-1937 season was $5.53 an acre.

3/ No ants active in any forage hole. The percentages of incomplete eradication are estimates based on the number of forage holes in which ants were active.

Table 1. - Colonies of _Atta_ _texana_ treated with CS_2 by C. R. Crawford Jan.-Mar. 1937, and checked by M. R. Smith in Aug. 1937 to determine the efficiency of the control measure

Colony	When treated	Size	Holes treated	Amount of CS_2 used	Time required		Efficiency of control
					CCC	Supervision	
Number	Date	Acres	Number	Pints	- - Man hours	- -	Percent
1	Jan. 27	1	125	10	3	1	94.6
2	30	3	300	24	4	4	100
3	Feb. 1	½	300	16	6	4	99.3
4	1	2	100	4	3	2	100
5	2	2	100	6	2	1	100
6	2	1½	120	6	3	-	100
7	2	3/4	120	16	4	-	99.3
8	4	½	-	-	4	-	100
10	4	1	100	6	2	1	100
11	5	3/4	75	4	1	1	100
12	5	¼	50	4	1	1	100
13	8	¼	70	4	2	-	100
14	8	¼	100	8	3	-	99
15	8	1¼	200	16	6	-	100
16	9	½	25	4	1	1	99.3
17	9	½	50	4	3	1	100
18*	10	1	100	8	3	2	almost 0
21	10	½	100	8	1	1	100
22	10	1	100	8	3	2	100
26	11	½	50	6	1	1	100
27	11	½	50	4	1½	-	99
28	24	1½	150	8	4½	1½	99.3
29	24	1¼	125	6	3	1½	100
32	24	1½	125	4	3	1	100
34	25	1	100	6	3	1	100
35	25	1	100	6	3	-	100
37	25	½	65	4	2	1	99.3
40	26	2	150	8	6	1	100
43	Mar. 2	¼	50	4	2	1	100
47	5	1	50	4	2	-	100
50	5	1	100	3	3	1	99.3
51	24	½	75	1½	1½	1	100
54	24	1	100	3	3	1	99.3
55	24	1	130	4	2	1	100
56	25	1¼	150	6	3	1	99.3
57	25	2	200	10	4	1	100
70	29	½	50	2	2	1	100
75	30	1	120	4	3	1	100

*The difference between these results and those found in the rest of the experiment indicate that the gas probably did not reach the colony.

Conclusions and Recommendations

It has been shown conclusively not only that the Texas leaf-cutting ant can be controlled with CS_2, if the colonies are treated thoroughly and at the proper time of year, but also that colonies can be eradicated, although in a small number of cases this may require more than one treatment. The ants can not become reestablished before the young trees reach a height beyond the stage of fatal injury. Since the planting season begins about Dec. 1 in the Kisatchie National Forest, it will be necessary to treat the colonies several weeks in advance; if it has been decided a year before planting what areas are to be planted the following year, the colonies can be treated during February and March of that year. The following method of treating ant colonies, devised by P. J. Ceremello, is recommended:

> "Planting areas will first be reconnoitered, and ant town locations noted on a map. This survey will allow an estimate to be made of the amount of carbon bisulphide needed and will also assist control during the treatment period. If, however, the planting crews locate towns that have not been treated, they should flag them and report them for treatment.
>
> All known ant colonies will be treated prior to planting.
>
> Field equipment for each man will consist of a 1-gallon can of bisulphide and a 5-foot section of ¼-inch enema tubing with a small funnel attached.
>
> The crew of two or more men (depending upon the size of the area to be treated) will gridiron the ant town by progressing along lines 10 feet apart, using flags, if necessary, and will treat one or two holes within each 10-foot square (100 square feet of area) as the crew progresses along the line. Especial attention should be given to the south, west, and east slopes.
>
> Since success of this treatment depends upon keeping bisulphide in and the fresh air out of the passages, it is very necessary to insert the tube deep down into the passage (best done by a twisting push) before the bisulphide is poured in, and be certain that all openings (not only the treated, but the untreated as well) are stamped closed.
>
> A lever-type clothes pin will be used on the tube just below the funnel to prevent the carbon bisulphide from passing through the tube until the funnel is filled. The same effect can be obtained by pinching or kinking the tube with the fingers.
>
> One funnel full of carbon bisulphide (approximately 1/10 pint, or 2 ounces) will be applied to each passage treated.
>
> Indications are that ants are most active during mild weather and least active on hot, cold, cloudy or rainy days. Treatment will be most effective on days of least activity for then the ants will be gathered in their chambers and chances of extermination will be good. However, do not wait for ideal days to treat known ant populations.

"Precautions

Carbon bisulphide is both poisonous and highly explosive and foremen should caution enrollees in its proper use. Smoking while using or in the vicinity of carbon bisulphide is prohibited because of its explosive qualities. Carbon bisulphide will be transported in suitable drums and on grounded trucks. Safety regulations as outlined in related correspondence will be observed in transporting and using this material. Foremen should explain reasons for caution to enrollees.

"Maps and records

A map of the area should show the location of each ant colony, using the symbols AC-1, AC-2, etc. The location of ant colonies will be marked on the ground with a temporary stake, or by a blazed nearby stump or scrub oak. One of these will be scribed with keel to show the ant colony number. A record (see enclosure) will be kept at camp and show progress of costs and treatment. The items listed are: Date of treatment, and for that day the ant colony number, acres treated, pints of bisulphide used, man hours for CCC and supervision and truck miles."

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Note: Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Projects 701-3-9 and 365-64-3-7.

OCCASIONAL PAPER NO. 85

AUGUST 9, 1939

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

TRUCK LOGGING WITH DETACHABLE TRAILERS

by

R. R. Reynolds,
Associate Forest Economist,
Southern Forest Experiment Station.

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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TRUCK LOGGING WITH DETACHABLE TRAILERS

by R. R. Reynolds,
Associate Forest Economist,
Southern Forest Experiment Station.

Introduction

The use of trucks and single- or dual-wheel trailers for logging in the South has increased very rapidly during the past 5 years. Because of the small initial investment, the small operating cost, and their extreme mobility and speed, in many cases trucks have replaced entirely the older railroad method of logging. Trucks also have helped to make possible partial or selective cutting, because a large tonnage of logs or pulpwood is not necessary to pay for the costly rights-of-way and spur tracks necessary in railroad logging.

Recent studies of truck logging made by the Southern Forest Experiment Station have shown that, although the truck method of logging is cheap and desirable, the method of loading the trucks generally is inefficient. This is mainly due to the fact that in loading a combination truck and trailer by cross haul it is necessary for the truck to remain idle during the loading for periods of 20 minutes to 1 hour (depending upon the size of the logs). Where the hauling distance is 7 to 10 miles (or less), the time "lost" in loading often would be sufficient to complete a round trip from the woods to the landing or mill with a load of logs.

Some lumber companies and logging contractors have increased the efficiency of logging trucks through the purchase and use of a machine-operated, boom-type loader mounted either on a truck or on a track-laying tractor. Many logging operators, however, have only a small amount of equipment and cannot afford to purchase a relatively expensive loader.

Nearly everyone that has been associated with truck logging at one time or another undoubtedly has thought of the possibility of using two trailers with each truck, in order that one may be loaded while the truck is on a trip to the landing with a load of logs on the other trailer. Possibly some attempts have been made to work out such a system, but most of these have failed because of (1) a weakness in the design of the device for supporting the trailer while being loaded or (2) the difficulty in coupling and uncoupling the loaded and empty trailers from the trucks.

A successful system, however, has been developed by A. G. Jacobson, Forester for the Fordyce Lumber Co. of Fordyce, Arkansas. This consists of an effective truck-hitch and a "horse" or standard that supports an empty, detached trailer in the woods while it is being loaded. This device also permits rapid and easy hooking to, and unhooking from, the truck of loaded or empty trailers.

Equipment Used and Method of Operation

Since the invention showed promise of making truck logging more effective and cheaper, the Southern Forest Experiment Station during the latter part of 1938 initiated a study of the use of this equipment. The object of the study was to determine the output per day per unit of equipment and the cost per unit of volume when hauling over various distances logs of average size from selectively cut, second-growth, shortleaf-loblolly pine-hardwood stands.

Previous experience had indicated that, except for very short hauls, the combination of one truck or tractor unit to two trailers and two standards or "horses" was the most effective. Also, except for hauls of more than about 18 miles, two loading teams and drivers and one chain puller or loaderman are necessary. This, therefore, was the equipment used throughout the study. The truck, which was of regular $1\frac{1}{2}$- to 2-ton rating and with 6 speeds forward, was equipped on the rear with dual wheels having 8.25- x 20-inch tires. The special combination fifth wheel and trailer hitch was mounted 6 inches ahead of the rear axle, in order to better equalize the load on both the front and rear wheels of the truck and thus keep the truck from jumping when starting with a heavy load. The specially built trailers were entirely of steel I-beam construction, with heavy axles and brake drums and with hydraulic-brake mountings. These were also equipped with dual wheels having 8.25- x 20-inch tires. Mounted over the springs and extending the entire length of the trailers were two well-braced I-beams, to which the bunks were fastened with U bolts. This construction eliminated the customary pole, permitted the easy adjustment of the bunks to take care of long or short logs, and made it possible to transform the log trailers into pulpwood trailers in only a few minutes. Both the ends of the bunks and the ends of the longitudinal I-beams were fitted with slots into which stakes could be placed. The "horses" or standards (see diagram), also constructed of heavy steel, consisted of two uprights spaced so that the rear truck wheels would exactly fit into a special runway built between them. The top of the uprights consisted of two heavy flat pieces of sheet steel built on an inclined plane with the bottom end about 3 inches lower than the upper portion, about 2 inches of which was bent parallel to the ground. The end of this level portion is fitted with a block or stop, and a catch or dog. Hinged to the frame on the outside are "wings" that can be placed so as to detach the trailer from the truck or turned out and away from the "horse" so that the trailer will pass through without being uncoupled from the truck.

In operation, the truck passes through the horse, stops momentarily until the wings are thrown into position to detach the trailer, and then proceeds Attached to the underside of the front bunk of the trailer, near the ends, are rollers which come in contact with, and roll up, the inclined plane, gradually lifting the trailer from the fifth wheel on the truck. The trailer, which is completely disconnected as the top or level portion is reached, is stopped by the blocks and held by the catches or dogs from rolling back down the inclined plane. In hooking to a loaded trailer, the truck backs into the horse, and the process is reversed.

When logs are being hauled, the truck drives through a horse that previously has been spotted for loading, drops the empty trailer, and drives to the trailer that has been loaded while the truck was hauling the previous load to the landing or mill. As soon as the truck leaves the woods with a load of logs, the empty standard is spotted in a location for another load, and the teams begin loading the empty trailer. In the present study, the loading was accomplished by means of the standard team cross-haul, but loading can be done by any method.

Records Obtained

Three different locations—one 9.8 miles, one 8.7 miles, and one 3.8 miles from the landing—were selected for the study, in order to determine the effect of distance (and roads) upon the cost of hauling, and in order to obtain logging conditions as typical as possible. In each case approximately 15 percent of the hauling distance was over ungraded woods roads and the remainder over gravel roads. The stands were cut selectively with the cut per acre ranging from 500 to 2,500 board feet. The following records were obtained:

1. Length of time required for the truck to exchange the empty trailer for a loaded one and begin the trip.
2. Travel time from woods to landing with load.
3. Unloading time at landing.
4. Travel time from landing to woods with empty trailer.
5. Delay time per trip.
6. Number of trips per day.
7. Number of logs per load.
8. Doyle and International Scale of each log and load.
9. Operating cost per day of truck, teams, and drivers.
10. Overhead, or ownership, costs per day.

Complete records were kept for a total of 21 operating days or for 156 loads. The ordinary standard bunk blocks were used on 128 loads, and on 28 loads specially built 30-inch stakes were used. All logs were cut into standard lengths of 12, 14, 16, and 18 feet, as required by the mill.

Results

As will be noted in table 1, the average amount of woods time, including the time required to unhook the empty trailer from the truck, to hook onto the loaded second trailer, and to start out of the woods with the load was 11.26 minutes per trip. The time required to haul a load of logs to the landing varied with the length of haul and also varied slightly from load to load for the same distance; on the average, however, it amounted to 3.45 minutes per mile of hauling distance. The unloading time averaged 11.11 minutes per load, and the time required to return to the woods with the empty trailer averaged 2.33 minutes per mile. To these figures must be added the time lost in making tire, truck, and trailer repairs and adjustments, and that caused by delays in hooking and unhooking the trailers, in unloading, etc. This amounted to 6.68 minutes per trip.

For a 5-mile haul, the total time per round trip amounted to 58.10 minutes; for a 10-mile haul, the total would be 87.15 minutes; for a 15-mile haul, it would be 116.20 minutes; and for a 20-mile haul, it would be 145.25 minutes. Throughout the study period the contractor's employees worked 8 hours per day, exclusive of the noon hour, and the contractor drove the truck on the last round trip each day; thus the truck was operated approximately 9 hours per day. On this basis, the number of round trips per day averaged approximately 10 for the 4-mile haul, 6½ for the 9-mile haul, and 6 for the 10-mile haul. On the same basis, 4½ trips would be made per 9-hour day on a 15-mile haul and 4 on a 20-mile haul.

Table 1.- Skidding, loading, and hauling cost per thousand board feet (Doyle scale) when using Jacobson standards and trailer equipment

Truck haul	Time per load				No. trips per day2/	Total haul per day		Total cost per day4/	Total cost per M board feet (Doyle scale)6/	
	Truck haul time	Truck return time	Other truck time1/	Total		Using bunk blocks 3/	Using stakes		Using bunk blocks	Using stakes
Miles	Minutes					Feet		Dollars		
4	13.92	9.32	29.05	52.29	10.33	16,745	19,741	31.69	1.89	1.61
5	17.40	11.65	29.05	58.10	9.29	15,059	17,753	31.69	2.10	1.79
6	20.88	13.98	29.05	63.91	8.45	13,697	16,148	31.69	2.31	1.96
7	24.36	16.31	29.05	69.72	7.75	12,563	14,810	31.69	2.52	2.14
8	27.84	18.64	29.05	75.53	7.15	11,590	13,664	31.69	2.73	2.32
9	31.32	20.97	29.05	81.34	6.64	10,763	12,689	31.69	2.94	2.50
10	34.80	23.30	29.05	87.15	6.20	10,050	11,848	31.69	3.15	2.67
11	38.28	25.63	29.05	92.96	5.81	9,418	11,103	31.69	3.36	2.85
12	41.76	27.96	29.05	98.77	5.47	8,867	10,453	31.69	3.57	3.03
13	45.24	30.29	29.05	104.58	5.16	8,364	9,861	31.69	3.79	3.21
14	48.72	32.62	29.05	110.39	4.89	7,927	9,345	31.69	4.00	3.39
15	52.20	34.95	29.05	116.20	4.65	7,538	8,886	31.69	4.20	3.57
16	55.68	37.28	29.05	122.01	4.43	7,181	8,466	31.69	4.41	3.74
17	59.16	39.61	29.05	127.82	4.22	6,841	8,064	31.69	4.63	3.93
18	62.64	41.94	29.05	133.63	4.04	6,549	7,720	5/25.19	3.85	3.26
19	66.12	44.27	29.05	139.44	3.87	6,273	7,396	26.19	4.02	3.41
20	69.60	46.60	29.05	145.25	3.72	6,030	7,109	25.19	4.18	3.54
21	73.08	48.93	29.05	151.06	3.57	5,787	6,822	25.19	4.35	3.69
22	76.56	51.26	29.05	156.87	3.44	5,576	6,574	25.19	4.52	3.83
23	80.04	53.59	29.05	162.68	3.32	5,382	6,345	25.19	4.68	3.97
24	83.52	55.92	29.05	168.49	3.20	5,187	6,115	25.19	4.86	4.12
25	87.00	58.25	29.05	174.30	3.10	5,025	5,924	25.19	5.01	4.25

1/ Woods time per trip, 11.26 minutes; unload time, 11.11; and delay time, 6.68 minutes.

2/ 9-hour day for contractor and truck, 8-hour day for employees; in dry weather.

3/ 1,621 board feet per load, Doyle scale.

4/ Truck cost $14.69; two teams and drivers, $13.00; chain puller, $2.00; and supervision, $2.00.

5/ Mileage at which one team can load truck; figure includes cost of only one team.

6/ Excluding contractor's profit.

The average load per trip when standard bunk blocks were used was 1,621 board feet Doyle scale, which is equivalent to about 2,273 board feet International $\frac{1}{4}$-inch scale. The average volume per load when the special 20-inch stakes were used was 1,911 board feet Doyle scale or approximately 2,680 feet International scale. The total volume hauled per day by one truck and two trailer units without special stakes was 16,745 board feet Doyle for a 4-mile haul; 10,763 for a 9-mile haul; and 10,050 for a 10-mile haul. For other distances, the volume that could be hauled has been computed in table 1.

As is to be expected, the original and operating costs of this equipment are greater than those of a truck and single trailer, and, as has been mentioned, two teams and drivers in place of the usual one per truck, are required per unit when the length of haul is less than approximately 17 miles.

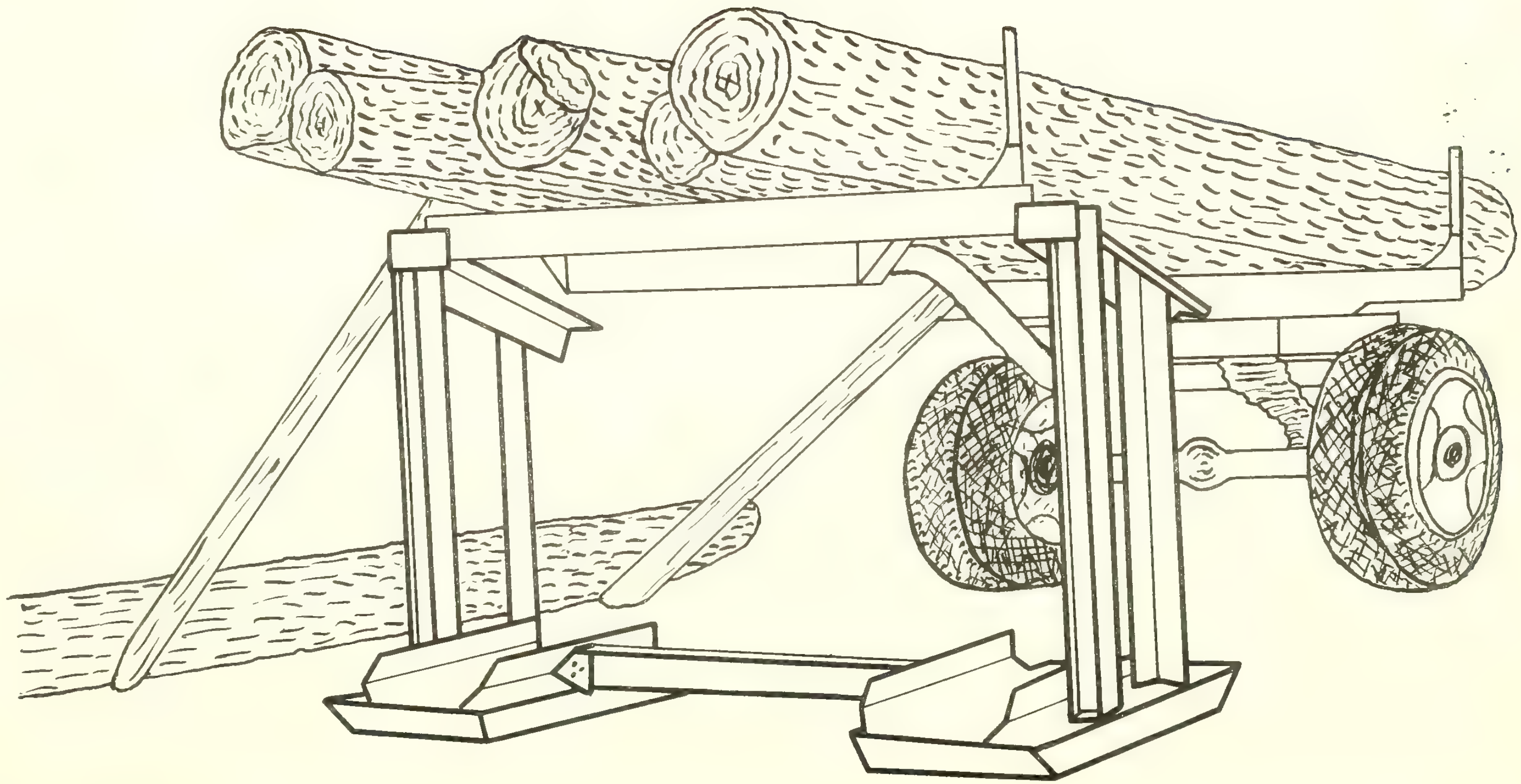
Based on the best available information on depreciation and cost of repairs, the total operating cost for the truck, trailers, and standards amounted to $14.69 per 8-hour day. This included depreciation, interest on the investment, license and taxes, gasoline, oil, tires, greasing, and cost of the driver. The cost of the two teams and drivers amounted to $13.00 per day. (For distances over 17 miles, however, the cost would be half this amount,or $6.50.) The chain-puller and top-loader cost $2.00 per day, and for supervision $2.00 more per day per unit was allowed. Thus, on distances up to 17 miles the total cost per day per unit would be $31.69, and for distances over 17 miles the total cost would be $25.19 per day.

The cost per M board feet Doyle scale when using standard bunk blocks amounted to $1.89 for the 4-mile haul, $2.94 for the 9-mile haul, and $3.15 for the 10-mile haul. Although no actual hauling was done over other distances, the cost can be computed with accuracy, since the only variable is the hauling time, which is based on number of minutes required to travel a stated distance. The costs for other distances, therefore, have been computed; they are given in table 1, in which is given also the cost per unit volume when special stakes are used in place of bunk blocks. As indicated, these figures do not include the contractor's profit and risk and, therefore, are net costs per unit volume.

These figures are of especial interest when compared with the cost of skidding, loading, and hauling with lighter trucks and single trailers under the system commonly used throughout the South. Under similar road and hauling conditions, and with logs of the same average size and length, this shuttle-type trailer system will undoubtedly produce logs $0.50 to $2.00 (depending upon the length of haul) per M board feet cheaper than the standard system. Further savings are also indicated, because additional use of this new and unusual equipment undoubtedly will bring about more efficiency. The amount of time spent in hooking, unhooking, and unloading apparently can be reduced considerably, and it seems entirely reasonable that by the use of stakes all loads can be built up to 2,000 board feet, roads permitting, regardless of the size of the logs.

Sufficient information on the possibilities of using this equipment for the hauling of pulpwood is not yet available, but it is known that the trailers will hold the equivalent of 5 standard cords of wood and that the full loads on the standards can be hooked onto as easily and effectively as can loads of logs. On a short test over a 10-mile haul, mostly on gravel roads, the truck and two trailers with two teams and wagons and five men loaded and hauled an average of about 23 standard cords per day.

DETACHABLE TRAILER AND "IRON HORSE"



OCCASIONAL PAPER NO. 86 OCTOBER 12, 1939

SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

A METHOD FOR INVENTORYING PLANTING STOCK IN FOREST NURSERIES

by

R. A. Chapman,
Associate Silviculturist,
Southern Forest Experiment Station.

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

Note: Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Project 365-64-3-7.

A METHOD FOR INVENTORYING PLANTING STOCK IN FOREST NURSERIES

By R. A. Chapman,
Associate Silviculturist,[1]
Southern Forest Experiment Station

Each year forest nurserymen are faced with the problem of estimating the number of seedlings they can ship from their nurseries. Since errors in the estimates may seriously affect the planting programs, during the past 2 years the Southern Forest Experiment Station has been attempting to improve nursery-inventory procedure. The inventory method that appears most promising consists of making two estimates: one of the total number of seedlings in the entire nursery, or a natural subdivision of it; and another of the percentage of plantable seedlings. With the data from these two estimates, the number of plantable seedlings in the nursery (or subdivision) can be calculated readily.

Estimating Total Number of Seedlings

To estimate the total number of seedlings, it is necessary to use sampling units. These may be of various sizes, but at this Station a unit 1 ft. wide by 4 ft. long has been used. The length of the sampling unit (4 ft.) corresponds to the width of the standard Forest Service seedbed, and by taking a sample that extends entirely across the bed, variation due to border effect is eliminated from the sampling variation. The width of the sample might be somewhat greater, but it should be remembered that for a given total area in samples, it is better to have many small samples than a few large ones.

The size of these sampling units must be measured accurately. As an aid in improving the accuracy, the Forest Service nurseries in the South use a light, rigid, steel frame 1 ft. by 4 ft. in size. This frame is placed across the seedbed, and seedlings falling inside it are recorded as being in the sample. When counting the seedlings in the sample, care should be exercised to record all the seedlings; counting all culls, regardless of size, eliminates any variations in personal judgment concerning what seedlings to count and what to omit, and also avoids any bias in grading.

The number of samples to take for any inventory depends on the variability of the beds being sampled and the accuracy desired. It has been observed that the large variation in numbers of seedlings per sampling unit is due mainly to variation between nursery beds. (A nursery bed is here considered as a unit 100 ft. long and 4 ft. wide.) Wherever there is a large variation between beds, the accuracy of the estimate of number of plantable seedlings can be increased by sampling in such a way that an equal number of sampling units falls in each bed. For longleaf and slash pine seedbeds in large nurseries, it has been found that if 1 percent of each bed is included in the samples, the error of the mean is about 3 percent.

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[1] Acknowledgement is hereby made of the useful suggestions received from P. C. Wakeley during the course of this study.

When only one sample is taken in each bed, however, it will be impossible to compute the accuracy of the estimate. If it is desired to compute the error of the mean, then at least two randomly located samples must be taken in each bed. A mechanical system of sampling which can not be considered as random is often used. It is possible (and even probable) that this type of sampling will give as accurate results as randomly selected plots, but since the plots are spaced mechanically, it is impossible to obtain a valid estimate of the accuracy of the inventory. The accuracy of mechanical sampling depends on the skill of the nurseryman in arranging his grid work of samples so that all sources of variability are sampled.

The procedure for obtaining a random sample can be shown most easily by an illustration. Assume that it is desired to take a 2-percent sample for inventory purposes. Also assume that the beds being sampled are 100 ft. long and the sampling unit to be used is 1 ft. wide. Thus each bed will contain 100 possible sampling units. The numbers from 1 to 100 are recorded separately on small slips of paper or tags that easily can be mixed thoroughly. Two numbers are drawn out and noted. These two numbers indicate the position of the sampling units to be counted in the first bed. The two numbers are put back in the box, the numbers are mixed again, and two more numbers are drawn. These numbers represent the sampling units to count for the second bed. This procedure is repeated for all beds. It should be noted that it is essential to mix the numbers thoroughly after each draw.2/

Having determined which samples are to be counted, it is necessary to find these sampling units in the field. If the man making the count is a fairly accurate pacer, the samples can be located by pacing. Assume that sample 75 is drawn; then the observer will pace in 75 ft. from the end of the bed and place the frame on the bed at this point. To avoid a possible bias, the observer should place the frame where his pace shows it should be, regardless of the kind of sample it will give. Always pace in from the same end of the bed.

Estimating the Percentage of Plantable Seedlings

The estimate of the percentage of plantable seedlings is usually obtained by digging the seedlings on a number of sampling units, but such a procedure is very laborious. It may happen also that an individual nurseryman "has a good eye" for estimating the percentage of plantable seedlings. Such an estimate is permissible, but it should be remembered that it is very difficult to make an unbiased estimate.

Also for some species of trees, the root and top characters or sizes

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2/ If one has access to a table of random numbers, it will not be necessary to record the sampling number on slips or tags and draw out samples; instead one can read the random numbers directly from the tables. Two sets of random numbers can be found in "Tracts for computers, No. 15. Random sampling numbers," by L. H. C. Tippett, Cambridge Univ. Press, London, 1927; and in "Statistical tables for biological, agricultural, and medical research," by R. A. Fisher and F. Yates, published by Oliver and Boyd, London, England, 1938.

are very highly correlated, in which case top grade can be used as a substitute for seedling grade. Where this is not true, and if the nurseryman lacks unusual skill in grading by tops alone, then the seedlings on a number of sampling units will have to be dug and graded. These units should be the same size as the units used to estimate the total number of seedlings. Care should be exercised to make sure that all seedlings are recorded that would have been if the samples had been used to estimate the total number of seedlings.

The average percentage of plantable seedlings could be estimated directly by digging all the sampling units used to estimate the total number of seedlings, but since this would be very expensive, use is made of the relation of percentage of seedlings plantable to total number of seedlings.

By making use of this relation it is possible to reduce the number of samples that have to be dug, which can be selected to cover the range of total number of seedlings per sampling unit. In choosing these samples for digging, care should be taken to let nothing but the range in density influence the choice, and particularly not to pick samples because of any observed or suspected plantable percentage. It is not necessary that the samples used in making the counts of total number of seedlings be used as part of this percent-plantable sample. If the range in density is not very large, 30 or 40 samples will be sufficient for most work, but the more samples taken the greater will be the accuracy.

The main inventory, which usually is made a month or so before actual lifting begins, is taken to supply an estimate of the number of plantable seedlings that will be present at lifting time. If the sampling is done when the seedlings are growing, later there is likely to be a change in grade, and it will be necessary to apply some sort of correction factor. This can be determined by experience or by noting, for each sample dug, which seedlings that are now classed as culls will be plantable by the time lifting begins.

In estimating change of grade, an endeavor should be made to estimate all causes of change. Two important sources of error in grade change are seedling growth, which causes an increase, and mechanical injury, which causes a decrease, in the number of plantable seedlings. The first of these errors depends on the ability of the grader to estimate what change will take place under the expected weather conditions. The second of these errors depends on soil conditions, on the lifting equipment, and on the care in its operation. If the seedlings are lifted when the soil is hard and tends to break into large lumps when the lifter is used, then a number of the seedlings may have to be culled because their roots have been broken off. If the lifting equipment is not skillfully used, a number of the seedlings will be injured and have to be culled. If one is either too optimistic or too pessimistic and assumes too large or too small a correction factor, an over- or underestimate will result.

Although one might think that the sample for determining total number of seedlings should be corrected for mortality during the period between inventory and lifting, this is not necessary if the mortality of plantable seedlings is estimated on the samples that are lifted.

All of these suggested corrections may make it appear that the estimate finally arrived at is only a guess. This criticism is partly true, but it should be noted that any procedure for estimating the plantable seedlings at a future date is subject to the same criticism. The accuracy of these corrections can be improved by additional study, and each nurseryman should try to develop a set of correction factors for his own nursery.

Calculation of Total Number of Plantable Seedlings

The samples taken to determine the total number of seedlings should be summed and averaged, in order to supply an estimate of the average total number of seedlings for all sampling units in the nursery or subdivision. From the other set of samples, on which number of plantable seedlings has been estimated, it is possible to compute the percentage of the total number of seedlings plantable. This percentage should be computed for each sample and plotted on a sheet of cross-section paper, plotting percentage of plantable seedlings over total number of seedlings. For the data available on southern pines, this curve has been found to be in most cases a nearly horizontal straight line passing through the mean percentage plantable.

Since a linear relation is indicated, the curve should pass through the mean of the percent plantable and the mean of the total number of seedlings. From this curve of percentage of plantable seedlings over total number of seedlings can be read the percentage of plantable seedlings corresponding to the average total number of seedlings obtained from the first set of samples.

The average number of plantable seedlings per sampling unit is the product of: (1) the average number of seedlings per sampling unit; (2) the corrected average percentage of plantable seedlings estimated from the relationship obtained from the second set of samples; and (3) a constant $\left(\frac{1}{100}\right)$ to convert the percentages to actual numbers.

The total number of plantable seedlings is then obtained by multiplying the average number of plantable seedlings per sampling unit by the total number of units being sampled.

To illustrate this computation, let us assume that the sampling has been completed and the following information compiled:

1. From the density samples, it has been found that the mean number of seedlings per sampling unit is 140.

2. From figure 1A, which represents the relation of percentage of plantable seedlings to density, the percentage of plantable seedlings corresponding to a density of 140 has been found to be 89.0.

3. The average number of plantable seedlings per sampling unit is then

$$140 \times \frac{89.0}{100} = 124.60$$

4. If the subdivision of the nursery contains 200 seedbeds, each

containing 100 sampling units, then the total number of seedlings is

$$200 \times 100 \times 124.60 = 2,492,000$$

Summary of Procedure

The procedure for inventorying seedlings in forest nurseries (just described in detail) can be outlined briefly as follows:

1. Obtain from one set of samples an estimate of the average number of all seedlings per sampling unit (a convenient unit is 1 ft. x 4 ft.).

2. Obtain from another set of samples the relation of percentage of plantable seedlings per sampling unit to the total number of seedlings per unit, and express by means of a curve.

3. From the curve obtained in step 2, determine the percentage of plantable seedlings that corresponds to the average number of seedlings found in step 1.

4. Multiply the percentage of plantable seedlings found in step 3 by the average number of seedlings found in step 1, and divide by 100 to get the estimated number of plantable seedlings per sampling unit.

5. Multiply this estimated number of plantable seedlings per sampling unit by the total number of sampling units in the group of beds.

(APPENDIX)

The Fitting of Curves

The steps discussed in the body of this report seem logical and simple, but when the nurseryman undertakes to apply them in his own nursery, he may find that the drawing of the curve of plantable percentage over the total number of seedlings (as called for in step 2) is an obstacle to his application of the inventory method. This obstacle is easily overcome, however, since it arises largely from unfamiliarity with the process of curve fitting.

Fitting curves to the type of data ordinarily obtained in nursery inventories involves no great difficulties, as can be shown by the example in table 1, in which columns 2 and 3 contain a record of the number of plantable and culled seedlings in each of twenty sample plots. The total number of seedlings in the sample is, of course, the sum of the two columns, as recorded in column 4. Column 5 contains the percentage of plantable seedlings—column 2 divided by column 4. A plot of the data in columns 4 and 5 is shown in figure 1A.

Table 1.– Original and derived data required for fitting rectilinear curves by the method of least squares

Observation number	Number of plantable seedlings	Number of culled seedlings	Total number of seedlings X	Percentage of plantable seedlings Y	X^2	XY
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	57	7	64	89.1	4,096	5,702.4
2	59	10	69	85.5	4,761	5,899.5
3	62	3	65	95.4	4,225	6,201.0
4	81	7	88	92.0	7,744	8,096.0
5	88	13	101	87.1	10,201	8,797.1
6	95	9	104	91.3	10,816	9,495.2
7	109	10	119	91.6	14,161	10,900.4
8	112	18	130	86.2	16,900	11,206.0
9	117	11	128	91.4	16,384	11,699.2
10	120	10	130	92.3	16,900	11,999.0
11	150	12	162	92.6	26,244	15,001.2
12	146	19	165	88.5	27,225	14,602.5
13	165	19	184	89.7	33,856	16,504.8
14	157	38	195	80.5	38,025	15,697.5
15	186	13	199	93.5	39,601	18,606.5
16	175	36	211	82.9	44,521	17,491.9
17	204	26	230	88.7	52,900	20,401.0
18	230	15	245	93.9	60,025	23,005.5
19	206	52	258	79.8	66,564	20,588.4
20	198	73	271	73.1	73,441	19,810.1
Total	2,717	401	3,118	1,765.1	568,590	271,705.2

There are two ways that a curve can be fitted to the data in the figure: one is by a mathematical method known as the "method of least squares;" the other is a graphic procedure commonly used by foresters. The mathematical method of curve fitting is more accurate (and therefore preferable) when the relationship between the two factors (percentage of plantable seedlings and total number of seedlings) can be represented as a straight line, but to use this method to the best advantage requires some knowledge of equations and curve shapes; the choice of the wrong equation may introduce as much error as careless curve fitting, especially if one endeavors to extrapolate the curve beyond the main range of the data. When the relationship between the two variables is curved, the graphic procedure may be easier, but great care should be exercised in drawing the curve. Draw the simplest, smoothest curve possible, and do not let the end points unduly influence its shape.

The Method of Least Squares

An inspection of figure 1A indicates that the relationship between the two factors there plotted can be represented by a straight line. The general equation for a straight line is

$$Y = a + b\ (X)$$

where

Y is the dependent variable (in this problem, the percentage of plantable seedlings); X is the independent variable (i.e., the total number of seedlings per sample); and a and b are constants whose values can be obtained by solving the two equations

$$a = \frac{[\Sigma Y]\ [\Sigma X^2] - [\Sigma X]\ [\Sigma XY]}{N\ [\Sigma X^2] - [\Sigma X]\ [\Sigma X]} \quad (1) \qquad\qquad b = \frac{N\ [\Sigma XY] - [\Sigma X]\ [\Sigma Y]}{N\ [\Sigma X^2] - [\Sigma X]\ [\Sigma X]} \quad (2)$$

In these equations, and in this example,

N = the number of observations, = 20;

ΣX = the sum of all the X values, or the total of column 4, = 3,118;

ΣX^2 = the sum of the squares of all the X values, or the total of column 6, = 568,590;

ΣY = the sum of all the Y values, or the total of column 5, = 1,765.1;

and ΣXY = the sum of the products of the individual X and Y, or the total of column 7, = 271,705.2.

Then, substituting the above values in equations (1) and (2), we get

$$a = 94.82$$
$$b = -.0421$$

The equation for the straight line shown in figure 1A thus becomes

$$Y = 94.82 - .0421\ (X)$$

The Graphic Method

If the data are not numerous, the curve can be fitted graphically to the individual points, but if the data are numerous the procedure becomes very tedious. To reduce the work of curve fitting, the data can be grouped by classes of the independent variable (in this case, the total number of seedlings per sample) and averaged. The curve can then be fitted to the averages of the various classes. The object of grouping is to reduce the number of individual points without losing any of the pertinent information supplied by the sample. If the data are distributed fairly uniformly over the range of the independent variable, about 10 groups or classes form a convenient and workable number. The data from table 1 have been grouped and assembled in table 2, columns 1 to 6.

The number of observations in each class-interval or group is shown in column 2. The sums of the X and Y values for each class-interval are shown in columns 3 and 4. These sums divided by the frequency values in column 2 are given in columns 5 and 6, respectively, and these means (columns 5 and 6) are the points plotted in figure 1B.

After plotting the averages, an attempt should be made to locate the best-fitting curve, which, if the relationship can be represented as a straight line, should pass through the mean X and Y (shown as a cross in fig. 1B). The slope of the line, which must be determined by inspection, should be that for which the sum of the squared residuals is a minimum. When computing the sum of the squared residuals for grouped data, it should be noted that each squared residual must be multiplied by the class frequency before summing.

To illustrate this curve-fitting procedure in detail, consider curve I, figure 1B. The curved value of Y for each X listed in column 5 (table 2) is read off from curve I and recorded in column 7. The residual Z listed in column 8 is the actual Y (column 6) minus the estimated Y (column 7); i.e., -2.1 = 90.0 - 92.1. In columns 9 and 10 are listed the products of the frequency column 2 and the residual column 8. If the product is positive, the result is entered in column 9; if negative, it is entered in column 10. The sums of these two columns, 20.6 and 20.4, are nearly equal, indicating that the curved values have been read very accurately. To obtain the sum of the squared residuals, the values in columns 9 or 10 are multiplied by the value in column 8 and entered in column 11, the sum of which (174.70) is the sum of the squared residuals.

To judge whether any other straight line fits the data better, consider the arbitrarily drawn lines, II and III, figure 1B. For these two lines, computations similar to those in columns 7 to 11 give the sums of the squared residuals 185.82 and 192.29, respectively. Since 174.70, the sum of the squared residuals for curve I, is smaller than either 185.82 or 192.29, curve I is the best fit.

Table 2.- Summary of data in table 1 and derived data required for fitting curves by the graphic method

Class interval	Frequency = f	Sum of X	Sum of Y	Mean X	Mean Y	Line #1				
						Estimates Y'	Residual $Y - Y' = Z$	f x (+Z)	f x (-Z)	f x Z^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
60 - 79	3	198	270.0	66.0	90.0	92.1	-2.1		6.3	13.23
80 - 99	1	88	92.0	88.0	92.0	91.2	8	.8		.64
100 - 119	3	324	270.0	108.0	90.0	90.3	- .3		.9	.27
120 - 139	3	388	269.9	129.3	90.0	89.4	.6	1.8		1.08
140 - 159										
160 - 179	2	327	181.1	163.5	90.6	87.9	2.7	5.4		14.58
180 - 199	3	578	263.7	192.7	87.9	86.7	1.2	3.6		4.32
200 - 219	1	211	82.9	211.0	82.9	85.9	-3.0		3.0	9.00
220 - 239	1	230	88.7	230.0	88.7	85.1	3.6	3.6		12.96
240 - 259	2	503	173.7	251.5	86.8	84.1	2.7	5.4		14.58
260 - 279	1	271	73.1	271.0	73.1	83.3	-10.2		10.2	104.04
Total	20	3,118	1,765.1	155.9	88.3			20.6	20.4	174.70

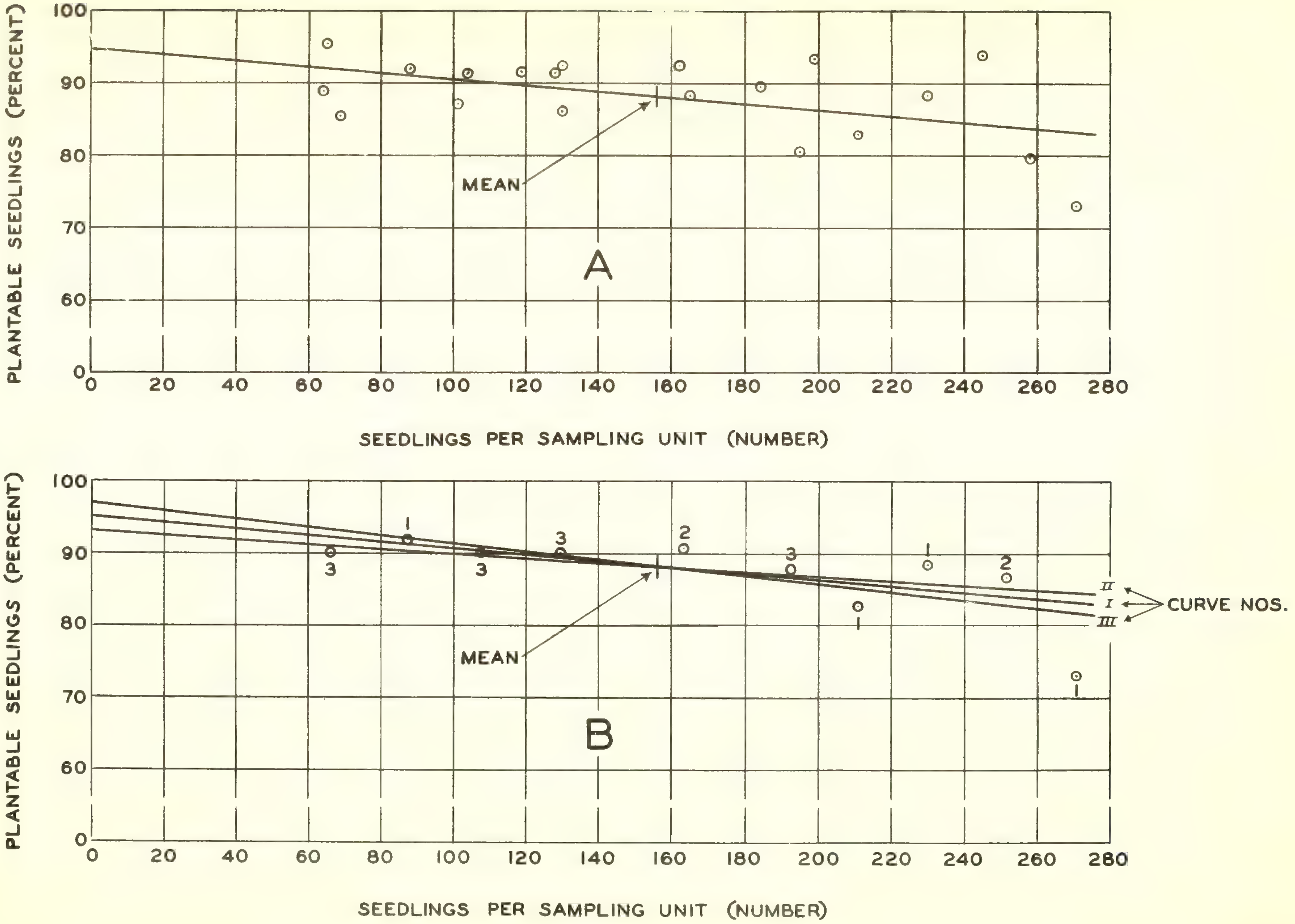

FIGURE 1 – SEEDLINGS PER SAMPLING UNIT PLOTTED AGAINST PERCENTAGE OF PLANTABLE SEEDLINGS.

OCCASIONAL PAPER NO. 87 NOVEMBER 10, 1939

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

A TENTATIVE FIRE-DANGER METER FOR THE LONGLEAF-SLASH PINE TYPE

by

C. A. Bickford, Associate Silviculturist,
and
David Bruce, Junior Forester,
Southern Forest Experiment Station.

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

A TENTATIVE FIRE-DANGER METER FOR THE LONGLEAF-SLASH PINE TYPE

By C. A. Bickford, Associate Silviculturist,
and David Bruce, Junior Forester,
Southern Forest Experiment Station.

A review of the larger fires in the South shows that many were not controlled while still small through failure to recognize the existing degree of fire danger. Ability to recognize dangerous fire conditions will not prevent fires from starting and spreading, but if the dispatcher can recognize dangerous conditions when they occur, he is in a better position to cope with these extreme conditions than otherwise. The size of a fire indicates not only the seriousness of fire conditions; it indicates also the promptness and effectiveness of the detection, dispatching, and suppression forces. Many fires that have been controlled during extremely hazardous conditions by use of adequate suppression forces and equipment, were potentially larger fires than some of those that "got away". Many fires on record, however, were over-manned. Overmanning may still be considered reasonable, as long as there are not more than about twice as many men as are needed; but when three and four times as many men are dispatched as are needed, the cost is excessive. The current rating of forest-fire danger can increase fire-control efficiency through reduction in the number of fires either under- or over-manned.

Fire-danger meters estimate by mechanical means the probable behavior of forest fires, as defined by the more significant variable elements of fire danger.1/ The longleaf-slash pine meter arbitrarily divides the range of values into classes of more or less uniform fire behavior. These classes are fixed to guide fire-control action, in presuppression and suppression. During days falling in the lowest danger class, only the year-long personnel are needed in the presuppression organization. As the conditions become more dangerous and the higher danger classes are reached, more and more of the temporary forces are assembled, until, in the highest danger class, every lookout station is manned, and all guards and patrolmen are on duty. At the same time, as the higher danger classes are reached, more men are required to control an individual fire, and there is a greater necessity for rapid and efficient detection and control.

1/ In the glossary of terms used in forest-fire control issued by the Forest Service in April 1939, "fire danger" is defined as "a general term expressing the sum total of both the constant and the variable factors which determine whether fires will start, spread, and do damage and that determine their difficulty of control. (Constant factors include values at stake, normal occurrence, fuel type, slope, aspect, soil type, etc. Variable factors include lightning, incendiary epidemics, illegal burning, inflammability, wind velocity, etc.)."

Fire danger in the longleaf-slash pine type changes rapidly and frequently. There is no long dry period or "fire season". Rather, there are short periods of high danger interspersed with periods of low danger, caused by rain or unsettled weather.

The fire-danger meter for the longleaf-slash pine type might be called more properly a meter for a predominantly herbaceous fuel type. This meter which has been called a longleaf-slash pine meter, to conform with the nomenclature of fuel-type mapping, is designed to be used where a herbaceous fuel largely determines the highest fire danger for the protected area.

A study of rate of spread of fire in the longleaf-slash pine type has been used as a basis for this tentative danger meter. Only four of the factors measured in analyzing the rate of spread were significant, namely, wind velocity, moisture content of fuel, fuel density, and age of "rough". An estimate of the rate-of-spread index,2/ based on these four factors would be of only limited value to a control organization, because (a) it would require an accurate map of fuel density and age of rough (which at times would need daily revisions), and also (b) it would require that the detection force locate the fire to the nearest acre. Furthermore, since omission of fuel density and age of rough lowered the correlation coefficient from 0.79 only to 0.75, it was decided to drop these variables, and a new analysis of rate of spread was made for the danger meter using only wind velocity and moisture content of fuel.

There are two main points to consider before using the rate of spread index for rating fire danger: Will it be possible to divide the rate of spread indices into fire-danger classes useful in guiding fire control?; and How can measurements taken at a central point be substituted for measurements of wind velocity and moisture content of fuel at the scene of a fire?

Division into danger classes is used to indicate changes in administrative action. The lower limit of the highest class should be fixed so that the highest class includes only emergency conditions. This class was determined by getting estimates of the actual increases in perimeter during a relatively small number of the worst fires that have occurred in the longleaf-slash pine type; from these data, the lower limit of the most

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2/ Rate of spread index is b in the formula for estimating the perimeter:

$$P = 0.26\, t^{b}$$

where P = total perimeter in chains;

t = total time in minutes from start of fire; and

b = a variable determined from rate of spread study, correlated with all significant factors except time.

The rate of spread, which is obviously the first derivative of the perimeter in respect to time (since it is the velocity at which the perimeter increases), $= \frac{dP}{dt} = (0.26)\,(b)\,(t^{b-1})$

hazardous class was estimated[3] to be at the rate-of-spread index 2.0.

The upper limit of the lowest class is set at the rate-of-spread index 0.8, which is obtained when there is no wind and the moisture content of the fuel is 40 percent. With a wind velocity of 1 mile an hour, it is necessary to have a moisture content of at least 56 percent to keep the index figure at 0.8 or less. With increasing wind, the moisture content of the fuel must get progressively higher to keep the index figure at or below 0.8. When these conditions prevail, fires cannot start with ordinary firebrands; this means that no administrative presuppression action is necessary.

In the absence of an adequate basis for defining the limits of the other danger classes, it was decided to make the class intervals equal in terms of rate-of-spread index. These class divisions may have to be modified, when more data are available.

The measurement of wind velocity and moisture content of fuel at a central point instead of at the scene of the fire will reduce the accuracy of danger estimates. If conditions at the central point represent worse than average conditions for the protection unit, however, the danger meter will not underestimate fire danger for the entire unit and also it probably will give a good estimate of the worst conditions.

To make it possible to determine fire-danger ratings quickly and easily, fuel moisture indicators[4] are used instead of fuel samples, which would have to be oven-dried before the moisture content could be found. In the rate-of-spread studies, the anemometer height is $3\frac{1}{2}$ ft., but to reduce the chances of the anemometer being molested and to conform with the height adopted as standard by the Appalachian Station, it was decided to change the height from $3\frac{1}{2}$ to $7\frac{1}{2}$ ft.

In correlating paired observations of actual moisture in the fuel with that registered by the indicators, the condition of the herbaceous vegetation was found to be a factor which affected the accuracy of the estimate. Separate analyses, therefore, were made for green, transitional, and cured herbaceous vegetation; and the values determined in these correlations were substituted for the fuel-moisture values in the equation for rate-of-spread index. The next step was to correlate paired observations of wind velocity at $3\frac{1}{2}$ ft. with the wind velocity at $7\frac{1}{2}$ ft. These values were substituted in the three equations previously derived.

The result is a set of three equations with the two independent variables, wind velocity and moisture content of an indicator, and

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[3] Since $P = 0.26\, t^b$,

$$\log P = \log 0.26 + b \log t$$

$$b = \frac{\log P - \log 0.26}{\log t}$$

[4] The fuel-moisture indicator to use with this danger meter is a set of three basswood slats prepared and issued by the Appalachian Forest Experiment Station. When the indicator is weighed on a special balance, the moisture content is read directly from the scale.

rate-of-spread index (and hence danger class) as the dependent variable.

From these formulae then the forest fire danger meter for the longleaf-slash pine type has been prepared as a slide rule. Detailed instructions for its use are issued to each fire-danger station set up. Briefly, these instructions are as follows: The scale for the prevailing herbaceous vegetation condition is used; the others are concealed by the face of the slide rule to prevent use of the wrong scale. At definite times each day, the wind velocity is determined and the fuel-moisture indicator is weighed on the special balance. To obtain the current fire-danger ratings, set the movable slide so that these measurements coincide; the arrow then shows the danger class and the rate-of-spread index. (It should be noted here that at any time during a rain the danger rating is class 1.)

No instructions or plans for administrative action are included with the danger meter at present, but without special instructions this meter should be useful as an aid in planning fire control. As one proceeds from class 1 (the lowest danger class, in which there is no need for manning towers) to class 5, the detection and suppression forces must be increased progressively. Although the danger meter does not include any direct measure of risk of fires starting, it may be possible to use it as an indicator of risk. For instance, incendiary fires usually will not be set when the danger rating is 1 or 2. A few will be set in days of class 3, but most will occur in days of class 4 and 5. No (or few) fires will be caused by carelessness with matches on days in danger class 1, but a few may be caused in days of class 2; and when the rating gets to be 3, 4, and 5, the likelihood of fires starting and spreading will increase.

When this tentative meter is checked, it is proposed to show the actual occurrence of fires, classified according to cause and final size on days in the various danger classes. Since the records kept will indicate rate-of-spread index, it is hoped that it will be possible to readjust the limits of the danger classes so that a definite percentage of the total number of fires may be expected to occur in days in each danger class. Also, if this meter proves satisfactory, it will be possible to state the average size of fire, and the average suppression force needed on days in each of the danger classes.

Although this danger meter is designed to measure fire danger at the time the wind and moisture readings are taken, it should be usable to predict fire danger for the next hour or day, by predicting what the wind and moisture conditions will be. Analysis of data taken at danger stations may show significant daily trends. Also examination of the Weather Bureau forecasts and local weather records may indicate for a given locality a method of forecasting the fire-danger rating.

This longleaf-slash pine fire danger meter is to be tested by the national forest protection units throughout the longleaf-slash pine type in the winter of 1939-1940. After it is used during this one fire season, it will be revised to improve its usefulness and accuracy if a revision seems warranted.

CUTTING AND PASTING INSTRUCTIONS

If desired, a working slide rule danger meter may be made from the figure on the last page as follows:

1. Cut off bottom block along heavy lines surrounding the moisture content scale for vegetation cured.

2. Mount the rest of the figure on light-weight, stiff cardboard.

3. Cut out the other three blocks along the heavy lines.

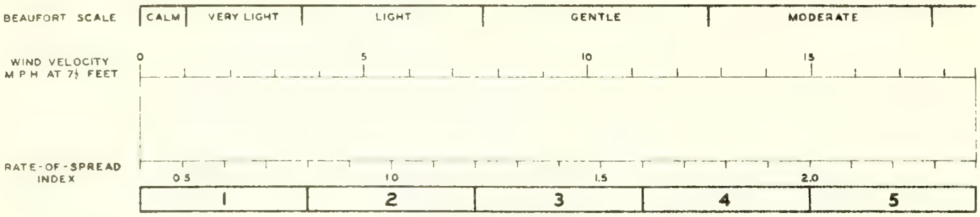
4. Cut out the window in the blank space of the title block between wind velocity and rate-of-spread index outlined by the light lines.

5. Paste the bottom block (showing moisture content scale for vegetation cured) on the other side of the cardboard on which is mounted the other moisture content scales.

6. Assemble as a slide rule by putting the moisture content scales in the middle; the two outside pieces are placed so that the printing faces out and the thumb openings coincide. Finally, bind the two long edges with 1/2" gum cloth mending tape.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.

LONGLEAF-SLASH PINE FIRE-DANGER METER



FIRE-DANGER CLASS

ISSUED BY UNITED STATES DEPARTMENT OF AGRICULTURE - FOREST SERVICE
SOUTHERN FOREST EXPERIMENT STATION - NOVEMBER, 1939 #1

ESTIMATED PERIMETERS AND RATES OF SPREAD FOR FIRES BURNING IN GRASS WITH NO BARRIERS
30 MINUTES AFTER DISCOVERY

FIRE-DANGER RATING	1		2		3		4	5
RATE-OF-SPREAD INDEX	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2
PERIMETER IN CHAINS	5	10	20	41	84	176	355	733
RATE-OF-SPREAD IN CHAINS OF PERIMETER PER MINUTE	0.1	0.3	0.6	1.5	3.6	8.4	19.2	43.3

DIRECTIONS: SET MEASURED MOISTURE CONTENT OF THE INDICATOR TO COINCIDE WITH MEASURED WIND VELOCITY;
THE ARROW POINTS TO CURRENT DANGER RATING

0 10 20 30 40 50 60 70 PERCENT MOISTURE, BASSWOOD INDICATOR

DANGER ↑ RATING

USE ONLY WHEN
FUEL IS GREEN

0 10 20 30 40 50 60 70 PERCENT MOISTURE, BASSWOOD INDICATOR

DANGER ↓ RATING

USE ONLY WHEN FUEL
IS IN TRANSITION STAGE

0 10 20 30 40 50 60 70 PERCENT MOISTURE, BASSWOOD INDICATOR

DANGER ↓ RATING

USE ONLY WHEN
FUEL IS CURED

OCCASIONAL PAPER NO. 88 DECEMBER 27, 1939

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FIRE-DISCOVERY TIME IN THE LONGLEAF-SLASH PINE TYPE

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FIRE-DISCOVERY TIME IN THE LONGLEAF-SLASH PINE TYPE

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The studies of rate of spread in the longleaf-slash pine type have provided a basis for estimating perimeters of fires burning under various conditions of weather and fuel and thus indirectly for determining the suppression action to be taken. For use on a specific fire, it is necessary to estimate either the time between origin and discovery (here called the discovery time) or the size of the fire when discovered. This estimate is a necessary link in the chain between the discovery of a fire and the departure of a crew to suppress it.

Results of 142 observations made on fires that were set mainly on the Biloxi Ranger District to measure rate of spread, showed that the average discovery time was nearly 10 minutes. It is better to use this average than a pure guess or than to make no allowance for the time interval between origin and discovery, but since it is obvious that a fire will be discovered sooner under favorable than under poor discovery conditions, it was decided to make a special study so that discovery time could be estimated under all conditions. In this study, therefore, which was undertaken to provide a means of estimating, in the longleaf-slash pine type, the discovery time of fires and their size when discovered, fires were set intentionally in 43 different places on the De Soto National Forest in southern Mississippi.

In making test fires, areas for the fires were chosen to give a minimum of suppression difficulty, but were selected at some distance from commonly travelled routes or occupied dwellings, in order to avoid any aggravation of the local fire-prevention problem. The selected areas were then located on the forest map1/ as accurately as possible without a formal survey. Six towers on or near the Biloxi Ranger District participated in this study; four of these were operated by the De Soto National Forest and two by the Mississippi Forest Service. All six towers were equipped in essentially the same manner; five used an Osborne fire finder, but none used hazemeters or binoculars. All kept a diary and daily log and had immediate access to a telephone (not a public line).

Arrangements were made with the local fire dispatcher for scheduled radio communication; all watches were set with the dispatcher's clock; and the weather instruments and radio were set up for use. Two fuel samples were taken by clipping grassy and other herbaceous fuel just above the ground surface. The area selected for burning was then staked at 1-chain intervals with small bamboo poles (flagged with various colors for speedy identification).

1/ The maps of the Biloxi and Leaf River Ranger Districts were prepared from aerial surveys, which made location to the nearest "forty" easy and positive.

When all these preliminaries were completed and checked, radio[2] communication was established with the dispatcher, who notified the field radio operator that he was ready. This operator then blew a whistle to signal the head mapper to start the fire and to begin the records with the weather instruments. As the fire spread, the radio operator stood by for word from the dispatcher that the fire had been discovered, the weather-instrument man took measurements of wind movement with the anemometer[3] at 1-minute intervals, and the mappers extended the staking system as needed at the head of the fire.

The towermen concerned did not know these plans and reported the test fires to the dispatcher as soon as detected exactly as they would any other fire. Both the first and second discoveries by towermen were reported to the field party, who marked the perimeters at the time of these discoveries with bamboo stakes. When discovery by the second towerman was reported, the fire was extinguished, and the radio operator obtained the essential data on discovery from the two (or three) towermen who reported the smoke. These data included name of tower, azimuth reading, distance of fire from each reporting tower, and visibility distance in the direction of the fire. Visibility distance is an ocular estimate made by the towermen, who used objects at known distances for reference.

When the fire was out, the two perimeters (at first and second discovery) were mapped and measured, guided by the bamboo stakes. The instruments were then taken down and the field party was ready to select another area for a test fire.

The moisture content of the fuel samples was determined in the field headquarters at the Harrison Experimental Forest.[4] Here also the mapped perimeters were checked, and the areas were measured with a planimeter. Separate correlation analyses were made, using time of discovery in minutes, perimeter at time of discovery in chains, and area at time of discovery in acres as dependent variables.

Reviewing the independent variables, it seemed reasonable to expect discovery time to vary as a joint function of (a) distance from fire to tower and (b) visibility distance. That is, as the distance from fire to tower increases with respect to visibility distance, discovery time should also increase; while as visibility distance increases with respect to distance from fire to tower, discovery time should decrease. This suggested using the ratio of the actual distance to the visibility distance as an independent variable, rather than using actual distance and visibility distance as two separate independent variables.

---

[2] The radio used in this study was a standard Forest Service set (type SPF radiophone) borrowed from the De Soto National Forest.

[3] The instrument used was a portable Biram anemometer. (See "Rate of spread of surface fires in the ponderosa pine type of California," by J. R. Curry and W. L. Fons. Jour. Agr. Res. 54 (4): fig. 2, p. 243. 1938.)

[4] Moisture content used in this study is percentage of dry weight; the drying was done with a Moisture Teller, an electrical device which blows warmed air through the sample.

This correlation proved to be significant ($M = 8.66$; $\sigma_{EST} = 5.78$; $R = 0.437$). Since the regression equation gave a relatively poor estimate, graphic tests for curvilinearity were made. A definitely curved relationship was shown between actual and estimated discovery time, in which actual exceeds estimated in both the low and high values but is less than estimated in the middle values. This means, in effect, that the influence of rate-of-spread index on discovery time is different for different ratios of actual distance to visibility distance. This seems reasonable in retrospect, since if the ratio of actual distance to visibility distance is relatively small (i.e., actual distance is small and visibility distance is large), it is to be expected that discovery time will be relatively small (short) for essentially all rate-of-spread indices. Similarly, when the ratio of actual distance to visibility distance is large (actual distance is large and visibility distance is small), discovery time should be large (long). When the ratios of actual distance to visibility distance are medium (i.e., when visibility distance is 1 to 3 times the actual distance), discovery time is much more affected by the rate-of-spread.

A curve was fitted to the data, in which actual discovery time was plotted over estimated discovery time. This was used as the graduating curve for the second estimate, a check of which showed that there were consistent and small underestimates in the lower values of discovery time.

A new curve was then drawn, and a third estimate was made; this is still not perfect, but further refinement seems unwarranted. In this step, the estimates of discovery time have been improved by reducing the curvilinearity and by increasing the correlation ($\rho = 0.651$, and $\sigma_{EST} = 5.02$ for the third estimate, compared with $R = 0.437$ and $\sigma_{EST} = 5.78$ for the first estimate).

The end product of this analysis is the accompanying alinement chart. It will be noted that discovery time on this chart is not graduated for less than 6.3 minutes. It is not to be inferred from this that fires cannot be discovered in less time; it does mean, however, that with the observed data, discovery time was too erratic to be satisfactorily estimated from the variables that were used, if the estimate of time is less than 6.3 minutes. The average of the 43 first discoveries was 6.93 minutes, whereas the average of the 86 independent (first and second) discoveries was 8.66 minutes.

It should be noted that most of the fires were set on days with good or fair visibility and had low to moderate rates of spread. It is obviously impracticable to set test fires on days when the rate of spread is high. This, together with the fact that the scanning time may form a large portion of the discovery time, prevents even reasonably accurate estimates below 6.3 minutes.

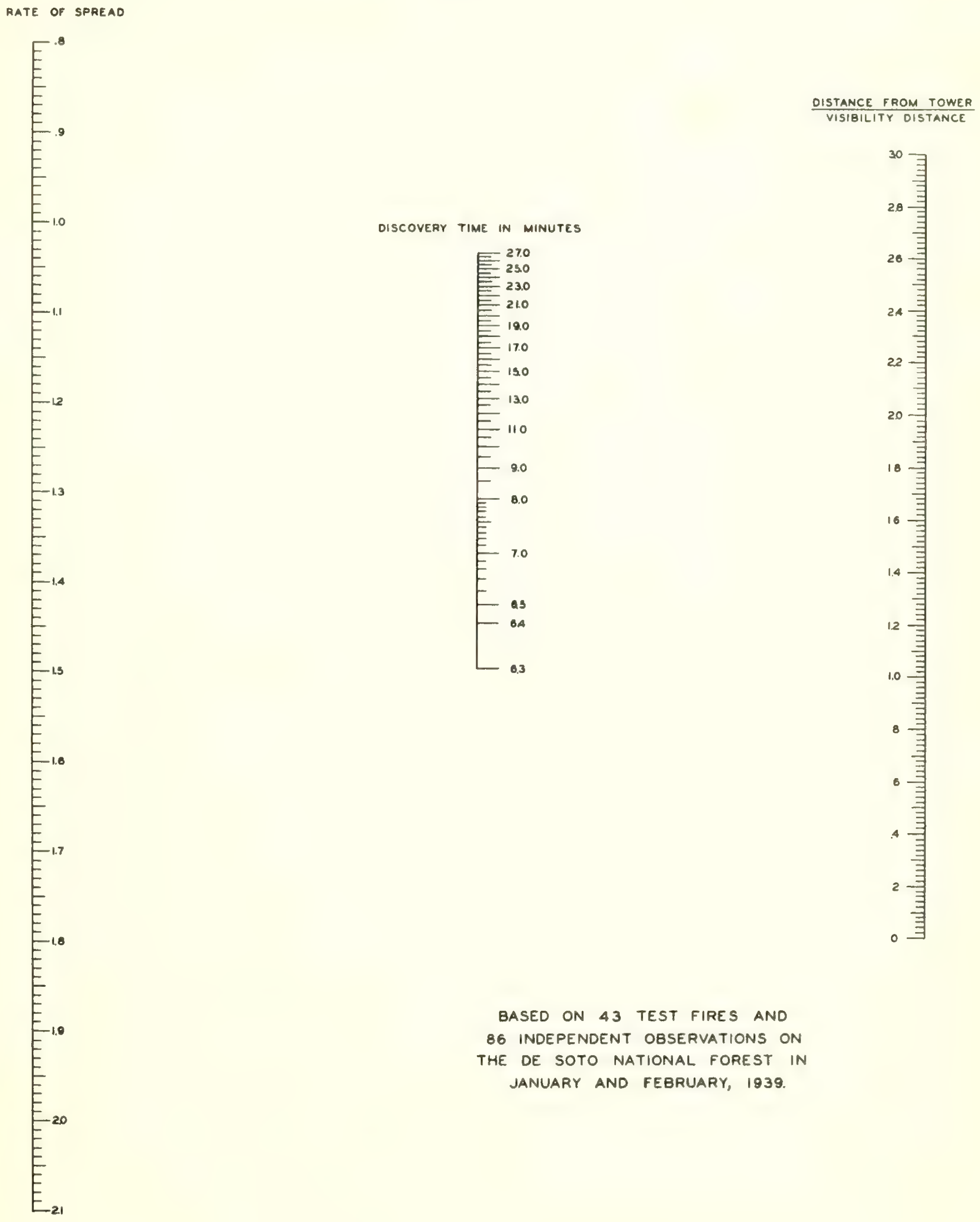
Similar analyses were made using perimeter at discovery and area at discovery as dependent variables. Both showed significant correlations, but neither was as good as the estimate of discovery time. Furthermore, discovery time is more useful because, if it is known, the perimeter can be estimated by using the rate-of-spread index, which may be read directly from the danger meter.

The study of discovery time has shown a definite correlation between discovery time and rate-of-spread index and the ratio of tower distance to visibility distance. This provides a means of estimating the discovery time of fires at various distances, if the visibility distance and the rate of spread are known. The discovery time, thus estimated, may then be combined with the expected travel time and the rate-of-spread index to estimate the size of fires when the suppression crew arrives. Furthermore, when more information is obtained on held-line construction, it may be possible to make a direct estimate of the number of men to send to any given fire.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.

RS-SS
PF CONTROL

ALINEMENT CHART OF DISCOVERY TIME IN THE LONGLEAF-SLASH PINE TYPE, AS ESTIMATED FROM RATE OF SPREAD, VISIBILITY DISTANCE, AND DISTANCE FROM FIRE TO TOWER



BASED ON 43 TEST FIRES AND
86 INDEPENDENT OBSERVATIONS ON
THE DE SOTO NATIONAL FOREST IN
JANUARY AND FEBRUARY, 1939.

OCCASIONAL PAPER NO. 89 APRIL 5, 1940

SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

TAXES ON FOREST PROPERTY IN FIVE SELECTED COUNTIES IN MISSISSIPPI, 1936 - 1939.

by

Ronald B. Craig, Associate Forest Economist,
Southern Forest Experiment Station.

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FOREWORD

The following tables relate to the ad valorem property taxes levied for State, county, school, and road purposes on forest land and timber in five selected counties of Mississippi. They contain the average assessed values and average taxes per acre, together with annual indexes, for the five counties as a whole and each county individually. The index base is the average of the three years 1937-38-39 as 100. The index figures indicate the trends in assessments and tax rates; for example, in Alcorn County the average assessed value per acre has moved downward for pine sawlog lands, while the corresponding average for clear-cut lands has moved upward. The years shown are those in which the tax is levied; i.e., data for "1936" relate to taxes levied in 1936 and payable in January 1937. Included in the "average tax per acre" of "sawlog" properties is the tax on such standing timber as was assessed thereon.

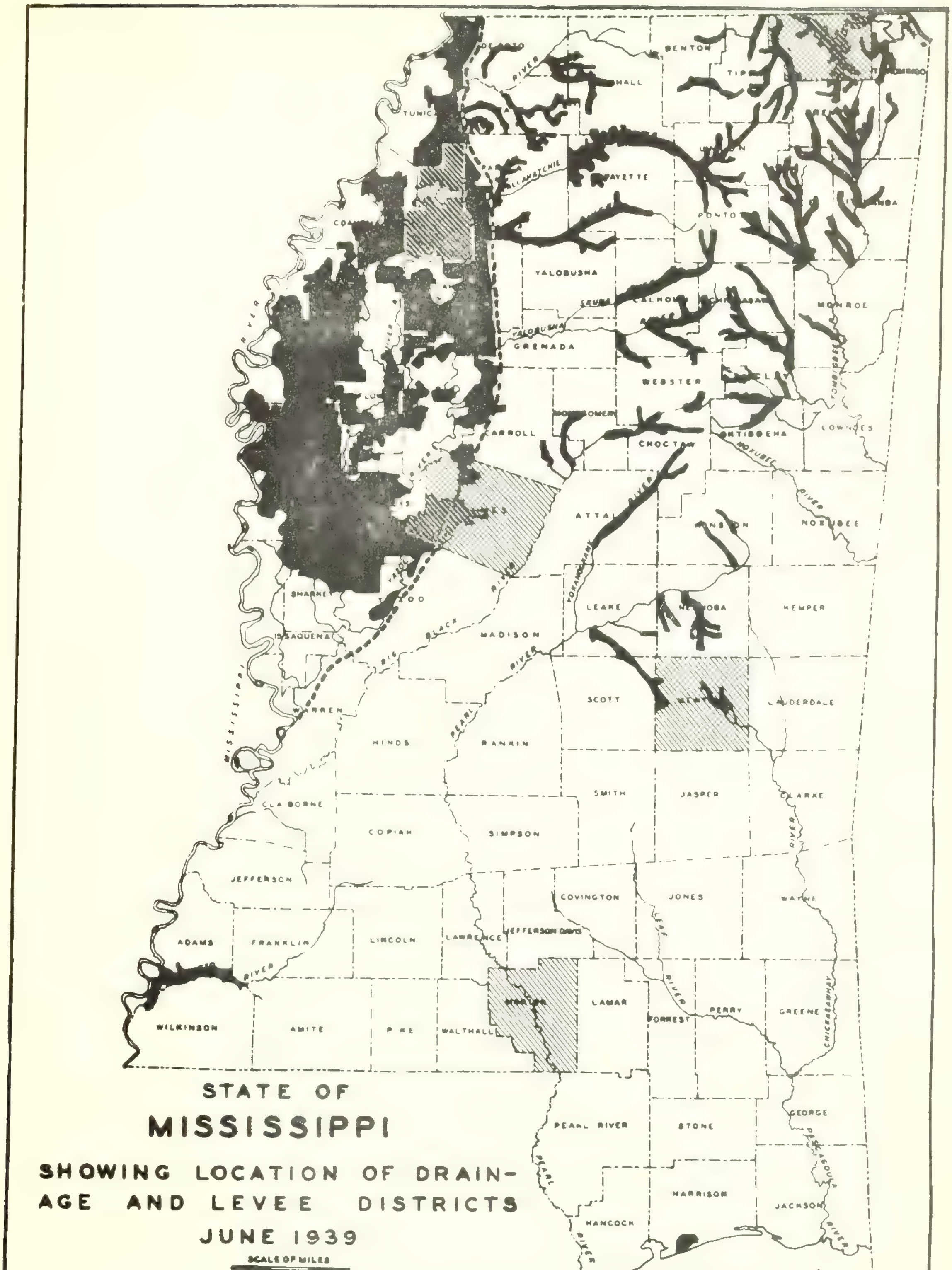
In the interest of simplification only three forest types have been recognized—pine, upland hardwoods, and bottomland hardwoods, the last-named including cypress. All surveyed lands were divided among these three types, in accordance with the character of the existing forest cover. A three-fold classification was also made with respect to stand condition, the recognized classes being sawlog size, under sawlog size, and clear-cut. Sawlog stands are those containing 600 or more bd. ft. per acre in sound trees of merchantable species, 9 inches or more in diameter for pine, and 13 inches or more in diameter for hardwoods. Under-sawlog-size stands are composed predominantly of trees sub-merchantable in size but 1 inch or more d.b.h., and containing less than 600 bd. ft. per acre. Clear-cut areas are those on which reproduction is quantitatively deficient, or on which the seedlings average less than 1 inch in diameter.

These tables are based on data obtained from local tax records for numerous typical forest properties scattered throughout each of the five counties; the properties were examined on the ground and classified as to forest type and condition-class. The five counties were selected as representative of conditions in all parts of the State. If feasible, data on other counties in Mississippi and in other States will later be assembled, and each year all data will be brought up-to-date and issued as a current annual report.

In addition to the ad valorem taxes for State, county, school, and road purposes shown in the following tables, forest land lying in the so-called Yazoo Delta (area between the broken line on map and the main levees along the Mississippi River) is subject to levee district taxes, ranging from 2 to 5 cents per acre during the four year period, 1936-39. Forest land lying in drainage districts (areas shown in solid black on map) is generally subject to drainage taxes, ranging in 1936 from $0.01 to $2.50 per acre, or occasionally more, and averaging about $0.40, and in 1940 from $0.01 to $2.00 per acre, with an average of about $0.30.

The counties covered by this report are shown on the map with shading.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.



STATE OF
MISSISSIPPI
SHOWING LOCATION OF DRAINAGE AND LEVEE DISTRICTS
JUNE 1939

Table 1.- Average of five selected counties,[1] Mississippi

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - Dollars - - - -				- - -Annual Index - - -				- - - - -Cents - - - - -				- - -Annual Index- - - -			
Pine:																
Sawlog	3.42	3.42	3.00	3.00	104	104	91	91	20.1	18.7	17.4	17.6	107	100	93	94
Under-sawlog	2.88	2.88	2.80	2.80	101	101	98	98	15.7	14.4	14.2	14.6	106	97	96	99
Clear-cut	2.66	2.66	2.58	2.58	101	101	98	98	14.8	13.5	13.3	13.6	106	97	96	98
Upland hardwoods:																
Sawlog	3.45	3.45	3.50	3.50	99	99	101	101	19.3	16.4	17.4	17.0	109	93	98	96
Under-sawlog	3.08	3.08	2.95	2.95	101	101	97	97	15.7	14.4	14.6	14.9	105	97	98	100
Bottomland hardwoods:																
Sawlog	3.65	3.65	3.52	3.52	101	101	98	98	23.6	21.7	22.7	22.5	104	96	100	99
Under-sawlog	3.45	3.45	3.37	3.37	101	101	99	99	18.7	16.8	17.7	17.4	106	95	100	98

1/ Alcorn, Holmes, Marion, Newton, and Quitman.

Table 2.- Alcorn County, Miss.

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - -Dollars- - - - -				- - -Annual Index - - -				- - - - -Cents- - - - -				- - -Annual Index - - -			
Pine:																
Sawlog	3.86	3.86	2.73	2.73	111	111	78	78	22.3	20.0	15.0	15.4	117	105	79	81
Under-sawlog	2.19	2.19	2.48	2.48	96	96	108	108	10.0	8.7	10.3	11.2	103	90	106	115
Clear-cut	1.50	1.50	1.62	1.62	97	97	105	105	7.2	6.3	7.1	7.4	104	91	103	107
Upland hardwoods:																
Sawlog	4.62	4.62	4.62	4.62	100	100	100	100	26.2	21.0	21.7	21.0	114	91	94	91
Under-sawlog	3.62	3.62	3.27	3.27	103	103	93	93	18.6	15.8	15.2	15.8	113	96	92	96
Bottomland hardwoods:																
Sawlog	4.27	4.27	3.90	3.90	103	103	94	94	26.8	24.3	27.2	27.4	103	93	104	105
Under-sawlog	3.75	3.75	3.38	3.38	103	103	93	93	19.0	16.1	15.7	16.3	112	95	93	96

Table 3.- Holmes County, Miss.

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - Dollars- - - -				- - - Annual Index- - - -				- - - - - Cents- - - - -				- - -Annual Index - - -			
Pine:																
Sawlog	2.83	2.83	2.78	2.78	101	101	99	99	13.3	13.6	13.9	14.0	98	100	102	103
Under-sawlog	2.47	2.47	2.38	2.38	101	101	98	98	11.4	11.6	11.6	11.8	99	101	101	103
Clear-cut	2.41	2.41	2.32	2.32	101	101	97	97	12.7	12.2	12.3	12.7	102	98	99	102
Upland hardwoods:																
Sawlog	2.28	2.28	2.37	2.37	99	99	103	103	12.4	11.8	13.0	13.1	100	95	105	106
Under-sawlog	2.53	2.53	2.63	2.63	99	99	103	103	12.8	12.9	14.0	14.0	97	98	106	106
Bottomland hardwoods:																
Sawlog	4.38	4.38	4.36	4.36	100	100	100	100	22.6	21.7	23.5	23.1	100	96	104	102
Under-sawlog	4.08	4.08	4.16	4.16	99	99	101	101	22.3	21.6	24.2	24.1	98	95	107	106

Table 4.- Marion County, Miss.

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	Dollars				Annual Index				Cents				Annual Index			
Pine:																
Sawlog	4.00	4.00	3.50	3.50	104	104	91	91	23.4	22.5	21.9	21.7	104	100	97	96
Under-sawlog	3.90	3.90	3.37	3.37	105	105	91	91	22.9	20.5	18.0	17.8	112	100	88	87
Clear-cut	3.74	3.74	3.37	3.37	103	103	93	93	21.2	19.3	17.5	17.5	110	100	91	91
Bottomland hardwoods:																
Sawlog	4.02	4.02	3.77	3.77	102	102	96	96	20.8	19.4	19.0	20.1	106	98	96	102
Under-sawlog	4.00	4.00	3.70	3.70	103	103	95	95	21.8	19.8	19.8	18.4	106	97	97	90

Table 5.- Newton County, Miss.

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - -Dollars- - - - -				- - - Annual Index- - - -				- - - - - - Cents- - - - -				- - -Annual Index- - - -			
Pine:																
Sawlog	3.00	3.00	3.00	3.00	100	100	100	100	21.4	18.8	18.8	19.2	109	95	95	97
Under-sawlog	2.97	2.97	2.97	2.97	100	100	100	100	18.6	16.6	17.1	17.4	107	95	98	100
Clear-cut	3.00	3.00	3.00	3.00	100	100	100	100	18.3	16.3	16.3	16.6	108	96	96	98
Bottomland hardwoods:																
Sawlog	3.00	3.00	3.00	3.00	100	100	100	100	35.2	31.6	31.4	30.0	108	97	96	92
Under-sawlog	2.99	2.99	2.99	2.99	100	100	100	100	18.6	16.1	16.2	16.5	109	95	95	97

Table 6.- Quitman County, Miss.

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	Dollars				Annual Index				Cents				Annual Index			
Bottomland hardwoods:																
Sawlog	2.56	2.56	2.59	2.59	100	100	101	101	12.7	11.6	12.5	11.8	103	94	102	96
Under-sawlog	2.44	2.44	2.60	2.60	98	98	104	104	11.6	10.5	12.7	11.8	100	91	109	102

OCCASIONAL PAPER NO. 89 (SUPPLEMENT) JUNE 5, 1940

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

TAXES ON FOREST PROPERTY IN TWO SELECTED COUNTIES IN MISSISSIPPI, 1936-1939, WITH STATE AVERAGES

by

Ronald B. Craig, Associate Forest Economist
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FOREWORD

This progress report supplements Occasional Paper No. 89, "Taxes on forest property in five selected counties in Mississippi, 1936-1939," issued April 5, 1940. The tables in this supplement present data on the ad valorem property taxes levied for State, county, school, and road purposes (but not for drainage or levee purposes) on forest land and timber in George and Webster Counties, Mississippi, and include a table of State averages based on seven counties: these two and the five counties reported upon in Occasional Paper No. 89 (Alcorn, Holmes, Marion, Newton, and Quitman). Further information in respect to the tables will be found in the "Foreword" of the previous report.

Because of the wide variation in assessment practice in respect to timber among both counties and the individual properties within any one county, the inclusion in the tables of average assessed values per acre of standing timber seemed of doubtful significance and they were therefore omitted. Taxes on timber, where levied, are included, however, in the tax per acre figures.

The reader may be assisted in interpreting these figures by a word as to their purpose and limitations. Their primary purpose is to show the general level of assessed value and taxes relative to forest land, together with the relative weight of taxation among the various classes of forest land. There is also some indication of the current trend in forest land taxation, and in time, similar figures covering a longer period of years will afford a valuable measure of this trend. It is, perhaps, unnecessary to point out that these figures do not reveal the tax situation of any particular property. If that is required, a special investigation is necessary, owing to frequent wide tax disparity among individual properties within the same county. These figures do afford, however, a basis for determining whether an individual property may be in an exceptionally favored or an overburdened condition, which might be more or less temporary.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.

Table 1.- State averages, Mississippi[1/]

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - -Dollars- - - - -				- - -Annual Index- - - -				- - - - - Cents - - - - -				- - - Annual Index- - - -			
Pine:																
Sawlog	3.41	3.41	3.00	3.00	104	104	92	92	24.2	22.2	21.1	22.2	108	99	94	99
Under-sawlog	2.88	2.88	2.77	2.77	101	101	98	98	16.6	14.9	14.4	15.0	108	97	94	98
Clear-cut	2.77	2.77	2.66	2.66	101	101	97	97	16.5	14.8	14.3	14.9	109	97	94	98
Upland hardwood:																
Sawlog	3.19	3.19	3.11	3.11	101	101	98	98	19.8	16.6	17.2	17.5	111	93	96	98
Under-sawlog	2.92	2.92	2.80	2.80	101	101	97	97	16.8	15.0	14.6	15.2	108	97	94	98
Bottomland hardwood:																
Sawlog	3.48	3.48	3.32	3.32	101	101	97	97	23.2	20.9	20.3	21.0	107	97	96	97
Under-sawlog	3.23	3.23	3.14	3.14	101	101	93	93	18.0	16.2	16.8	16.9	106	95	99	99

1/ Based on data from seven counties—Alcorn, George, Holmes, Marion, Newton, Quitman, and Webster.

Table 2.- George County, Miss.[1]

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - -Dollars- - - - -				- - - Annual Index- - - -				- - - - - Cents- - - - - -				- - - Annual Index- - - -			
Pine:																
Sawlog	3.50	3.50	3.50	3.50	100	100	100	100	20.9	20.1	21.4	23.8	100	97	103	114
Under-sawlog	3.29	3.29	3.12	3.12	102	102	97	97	16.6	14.9	14.3	15.2	108	97	93	99
Clear-cut	3.03	3.03	2.95	2.95	101	101	93	98	15.0	13.5	13.2	14.3	108	97	95	103
Upland hardwood:																
Under-sawlog	3.05	3.05	3.01	3.01	100	100	99	99	15.6	13.9	13.5	14.4	109	97	94	101
Bottomland hardwood:																
Sawlog	3.10	3.10	3.00	3.00	101	101	93	98	17.8	15.6	14.3	15.8	111	97	92	98
Under-sawlog	2.96	2.96	2.99	2.99	100	100	101	101	15.4	14.0	14.0	15.1	106	97	97	104

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[1] In addition to the ad valorem taxes shown, all forest land in George County is taxed 2 cents per acre for fire protection purposes.

Table 3.- Webster County, Miss.

Forest type and condition-class	Average assessed value per acre				Index of assessed value per acre				Average tax per acre				Index of tax per acre			
	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939	1936	1937	1938	1939
	- - - - -Dollars- - - - -				- - - Annual Index- - - -				- - - - - Cents- - - - - -				- - - Annual Index- - - -			
Pine:																
Sawlog	3.29	3.29	2.48	2.48	109	109	82	82	43.8	38.3	35.7	39.4	111	97	91	100
Under-sawlog	2.46	2.46	2.29	2.29	102	102	95	95	19.9	17.2	15.4	16.8	114	98	83	96
Clear-cut	2.92	2.92	2.68	2.68	103	103	94	94	24.8	21.0	19.2	21.0	114	97	88	97
Upland hardwood:																
Sawlog	2.67	2.67	2.33	2.33	104	104	91	91	20.9	17.1	17.0	18.5	114	93	93	101
Under-sawlog	2.47	2.47	2.28	2.28	102	102	95	95	20.4	17.5	15.5	16.6	115	98	87	93
Bottomland hardwood:																
Sawlog	3.00	3.00	2.64	2.64	104	104	92	92	26.6	22.2	17.0	18.5	121	101	78	84
Under-sawlog	2.40	2.40	2.17	2.17	103	103	94	94	17.0	15.6	14.9	15.9	103	99	94	101

OCCASIONAL PAPER NO. 90

APRIL 18, 1940

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SOUTHERN FOREST EXPERIMENT STATION

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New Orleans, La.

FOREST RESEARCH AND THE SOUTHERN LUMBER INDUSTRY

by

E. L. Demmon, Director
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FOREST RESEARCH AND THE SOUTHERN LUMBER INDUSTRY*

By E. L. Demmon,
Director, Southern Forest Experiment Station

Permanent, successful, forest-land management must rest upon a sound foundation of knowledge—derived through forest research. In general, forest research must be fostered and advanced by public agencies, first, because it is inefficient for each landowner to undertake,alone,research for his individual land; secondly, because the public is by far the largest single owner of forest land; and finally, because in a long-time undertaking such as forest research, public agencies alone can be expected to provide the necessary stability of program. The responsibility of the Federal Government for forest research has been recognized in the establishment of 12 regional forest experiment stations throughout the United States.

The opportunities for forestry here in the South are not excelled in any other forested region of the United States. Here we have a vast area of exceptionally productive forest land supporting a variety of native trees valuable for many products; the climate and soils are favorable for rapid tree growth; we have relatively easy logging conditions, and are in close proximity to the world's greatest timber market. This forest is at present furnishing raw material for more than 10,000 industrial plants using forest products, and providing more than 50 million man-days' employment each year.

The foremost customers of forest research should be those owners and managers of forest lands who are interested in ascertaining the best forest management practices for their properties. In the South, those potential customers are primarily private landowners or their representatives, since about 93 percent of the region's forest land is in their hands. Of this immense area of privately owned southern forest land, it is estimated that somewhat over one-third is in farm woodlands, the remainder being in industrial and other holdings.

The Southern Forest Experiment Station serves the Lower South, a territory extending from Florida and Georgia to Texas and Oklahoma. There are approximately 122 million acres of forest land within these boundaries, representing about 60 percent of the total land area. Forest research at the Southern Forest Experiment Station was initiated on a small scale in 1921. Since then its program has been expanded gradually, and, within the limitations of funds available, it has sought answers to many of the problems of forest protection and management and of best forest-land use confronting this region. During this time, much has been learned about what constitutes good forestry practices, but forest research is necessarily a long-time undertaking. This is true even in a region of rapid tree growth such as the South, because the complexity of forest soils, forest types and conditions, the variety of forest products, and the multiple uses of forest lands result in so many problems demanding solutions. Because the most important forest problems in the Station territory have seemed to be concerned with timber growing in the pine region, practically all of the Station's limited funds thus far have gone into outhern pine studies. This does not mean that the importance of the southern ardwoods has been overlooked, but rather that a choice was made as to where imited finances could yield the largest and most immediate benefits to the ublic.

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* Address before the 25th Annual Meeting of the Southern Pine Association in New Orleans, La., March 28, 1940.

The Southern Forest Experiment Station maintains its headquarters in ew Orleans. Its main research activities, however, are centered on 9 experimen- al forests, representative of the major forest types, where investigations of the orest problems in those particular types are conducted. These experimental orests are publicly owned, and are usually adjacent to, or parts of, national orests. They serve as field laboratories for conducting fundamental and applied orest research and as demonstration areas where lumbermen and others can see, n the ground, the results of forestry practices. Since each of these centers f work is typical of forest conditions in its section, the results of these ield investigations are applicable over wide areas and broad forest types. hese experimental forests include the following:

NAME	LOCATION	HEADQUARTERS TOWN	AREA IN ACRES	FOREST TYPE	PRIMARY RESEARCH
Olustee	Osceola N. F.	Lake City, Fla.	2,961	Longleaf-slash	Naval Stores management
Hitchiti	Georgia Piedmont	Macon, Ga.	4,735	Shortleaf-loblolly	Forest management
Harrison ncl.McNeill)	DeSoto N. F.	Saucier, Miss.	3,850(Har.) 1,210(McN.)	Longleaf-slash	Silviculture
Chewalla	Holly Springs N. F.	Holly Springs, Miss.	2,500(est.)	Upland hardwoods	Forest influences
Delta	Mississippi Delta	Stoneville, Miss.	2,580	Bottomland hardwoods	Hardwood management
Palustris	Kisatchie N. F.	Alexandria, La.	4,100	Longleaf	Artificial forestation & fire studies
San Jacinto	Sam Houston N. F.	Huntsville, Tex.	2,150	Shortleaf-loblolly	Pulpwood management
Crossett	Southern Ark.	Crossett, Ark.	1,686	Shortleaf-loblolly	Financial aspects of forestry
Irons Fork	Ouachita N. F.	Mena, Ark.	9,000(est.)	Shortleaf-hardwoods	Forest influences

The Southern Forest Experiment Station is organized in divisions, for hich technical personnel are chosen on the basis of aptitude and training.

The men in the Division of Forest Management research concentrate upon udies of thinnings, improvement cuttings, naval stores operations, forest anting, forest soils, timber growth and yield, and forest fires, while special- sts detailed from cooperating bureaus take care of forest diseases, problems f stain and decay, forest insects, and wildlife and game.

The staff assigned to Forest Economics covers several projects. These nvolve studies of: (1) the costs and returns from industrial operations and the ossibilities of profits, for different objectives and for various forest types;

(2) the amount of and trends in taxation; (3) the feasibility (from the standpoint of sustained-yield forestry) of various forms of economic and financial organization; and (4) the forest survey. This latter group has cruised the entire Lower South, in units of from 5 to 10 million acres, and is reporting on stand, growth, drain and future market requirements, and land use.

The Division of Forest Influences staff is studying the effect of forests on water conservation, erosion, and streamflow, as a basis for determining sound watershed management practices. Flood control surveys are being made in cooperation with other bureaus of the Department of Agriculture, to determine flood damages and the extent to which land-use and other upstream control measures are feasible in retarding flood-flows and in preventing soil erosion.

The southern lumber industry is today in a state of transition. The day of exploitation based on liquidating virgin forest stands is about over. The forest survey tells us that less than 15 percent of the present forest area remains in old-growth timber. For the past several years, more than half the lumber produced in the South has come from second-growth stands, and that proportion will increase until in a few years all southern lumber will come from such stands. By and large, this second crop of timber has come up with very little care or attention. The beginnings of forest protection and forest management were made over 20 years ago by such pioneers as "Uncle Henry" Hardtner of Urania, and Col. Wm. H. Sullivan of Bogalusa, La., and rapid strides have been made in recent years in adopting conservative forest-management practices. Nevertheless, the recently completed forest survey shows clearly that southern forests are growing at less than 50 percent of their potential capacity, and that many stands are made up of widely spaced, fire-scarred, limby trees of poor quality and low value. This picture presents both a challenge and an opportunity. There is a big job ahead in rebuilding this great natural resource to its maximum usefulness. As this is accomplished, however, it will bring its reward in increased outlets for both capital and labor, to the benefit of the entire region.

I will now discuss some of the forest problems confronting owners of southern forest lands and relate briefly what the Southern Station is doing about them. One of the first essentials of a management plan for any forest property concerns harvesting practices—the operator needs to know when to cut and which trees should be removed and which left, to insure maximum growth and financial returns; which trees are needed as a source of seed; how open-grown stands can be brought to full capacity; how the more valuable species can be favored and the less valuable eliminated; when and to what extent young stands can be thinned or improvement cuttings made advantageously; when pruning can be justified, and how and when it should be done; and many other similar questions which must be answered for each of the many forest types, for many different sub-regions, and with several different objectives of management in mind. The Station does not have final answers to these questions, but it has made progress in obtaining solutions to all of them. Study plots, located chiefly on experimental forests, have yielded many preliminary results. The findings indicate strongly the benefits of conservative cutting practices, and in fact are now being used by a number of progressive forest owners.

For the shortleaf and loblolly pine types, frequent and light cuttings (known commonly as "selective cuttings"), judiciously applied, have been found feasible, and seem to promise maximum growth in quantity and quality. Actual case studies also indicate that stand-improvement cuttings can often be made at an immediate profit. In many cases, worthless and undesirable hardwoods can be killed readily by girdling. Studies of pruning have also been started but have not progressed sufficiently to justify conclusions.

Volume and yield tables, giving the contents of trees of different sizes and potential rates of growth of second-growth, fully stocked stands of the four principal southern pines and of red gum, have been published. Closely related to growth rate is site quality, which is expressed as an index figure and represents potential soil productivity in terms of timber production. The Station is now preparing maps showing average forest productivity zones for the Lower South.

The specific requirements for obtaining adequate natural reproduction of the southern pines have been given considerable study by the Southern Station and broad general measures are now known. In brief, 2 to 4 well-distributed good seed trees per acre are ample to insure restocking of shortleaf, loblolly and slash pines, assuming, of course, proper protection from fire. Natural reproduction of longleaf is much more difficult to obtain than that of the other southern pines, because of the infrequency of longleaf seed crops, the need for optimum seedbed conditions, early competition with other plant growth, the brown-spot needle disease, and depredations of birds, rodents, and hogs. Four to six good longleaf seed trees per acre, well spaced, may be sufficient to obtain natural reproduction, but the factors of seedbed, disease, competition, etc., must also be properly controlled. Leaving a few scattered pine seed trees is merely a minimum measure to prevent forest devastation, and should not be considered a substitute for good forest management. While much additional information is needed before optimum silvicultural measures can be definitely recommended, the practice of at least these minimum requirements need not be delayed.

Estimates of the southern pine lands in need of forest planting exceed 20 million acres, depending upon the purpose to be served and the economic returns expected. This area includes more than 5 million acres of cut-over longleaf pine land so devoid of tree growth that no merchantable stand seems likely to reproduce naturally for many years. It includes in addition a great acreage of longleaf and other lands only partly stocked, on which planting is needed to bring the land promptly to economic productivity, and also a vast acreage of abandoned fields. Approximately 500,000 acres in the Lower South have already been planted to forest trees, with very general though not with complete success. The combined planting program of both public and private agencies includes the reforestation of between 75,000 and 100,000 acres of trees annually during the next few years, at a yearly cost in excess of half a million dollars. To date, Station studies have yielded many important facts fundamental to all phases of planting, but the continually expanding planting program continues to bring forth new problems that require much additional research.

An outstanding forest problem in the South, as in practically all forest regions, is protection from fire. In spite of the widespread publicity given to fire damage, the South continues to burn about 20 percent of its forest lands annually. This region has the unenviable distinction of having more than 75 percent of all the fires and more than 90 percent of all area burned in the United States. Only about half the South's forest land is under organized fire protection, and practically all this progress has been made in the last 20 years. Fortunately for the South, forest fires here do not cause damage comparable to that in other regions. Actually, fires have occurred rather frequently throughout the South since earliest historical times, and forest areas that have never burned are exceedingly rare. Although southern forests are relatively resistant to the typical surface fires, in the aggregate a great amount of damage is incurred each year through destruction of tree seedlings, scarring of trees, and retardation of growth. On the other hand, fire, when properly controlled, may have beneficial effects for silvicultural and protection purposes under certain circumstances and in game and range management. Adequate control of fire, however, is a first essential to the practice of forestry in the South, and any use of fire must be technically sound and correctly adapted to the owner's purpose in managing the land. The Southern Station is studying: (1) the effects of fire, as a basis for making fire damage appraisals; (2) fire behavior and control, including an analysis of fire danger and the development of a fire-danger meter, to increase the efficiency of fire control organizations; and (3) the economical and effective use of fire in forest management.

A sound forestry program must be based on the management and utilization of our forest resources in the best interests of the individual, the community, and the nation. If our forests are to contribute their full quota of usefulness in terms of maximum income and employment on a stable, permanent basis, we need a sound foundation in forest economics. The Southern Station has made a start in obtaining this information in its studies of (1) the financial aspects of private forestry; (2) forest taxation and the cause and effects of widespread tax forfeiture; (3) the factors governing forest industry ownership in its policy of forest land management; and (4) the forest survey.

Information on the costs and returns of timber growing is essential in determining the all-important question, "Will it pay?" The answer to this question is particularly important in the South, where about 93 percent of the commercial forest land and 95 percent of the saw-timber volume is presently in private ownership. Station studies in the shortleaf-loblolly pine region have developed information that (1) logging of trees below certain sizes not only does not pay, but also materially curtails the growth rate of the forest; (2) selective cutting under both virgin and second-growth forest conditions usually is feasible; (3) cuts as light as 500 board feet per acre often are possible, particularly where truck logging is used; (4) tractor logging can be used profitably under certain conditions; (5) top logs often can be utilized more profitably for pulpwood than for sawlogs; (6) thinnings and stand improvement cuttings often can be made at an immediate profit, as well as to the advantage of future quality and quantity growth.

The forest survey of the South, begun in 1930, includes an inventory of the present supplies of standing timber and other forest products, an estimate of the current growth rate, mortality rate, and industrial drain, and a study of future forest-products requirements. It is supplying basic information of essential importance in the formulation of sound regional policies for effective and rational use of forest land. Field work has been largely completed and the computation and interpretation of the field data and publication of the results are progressing steadily. Reports on the forest situation by survey units have been issued for nearly every section of the Station territory, and State and regional reports are being prepared.

Among the outstanding survey findings have been that the sound-tree growing stock of usable timber in the Lower South totals about 255 billion board feet, lumber tally (56 percent pine, 44 percent hardwoods and cypress), or 1.1 billion rough cords (48 percent pine, 52 percent hardwoods and cypress). In 1936, growth was 16.3 billion board feet of saw timber, or 62.1 million cords for the entire growing stock; whereas drain, including mortality, was 17.3 billion board feet of saw timber, or 55.6 million cords total. In 1937, comparable data showed a growth of 16.4 billion board feet of saw timber, or 62.9 million cords total, with a saw-timber drain of 17.9 billion board feet, and a total drain of 57.2 million cords.

The causes for nonpayment of taxes and the uses of land thereby forfeited to public ownership are also under investigation. Land so forfeited in 8 southern states totaled approximately 31 million acres in 1934, of which about 17 million acres was forest land, mostly in poor growing condition. This extensive delinquency is largely the result of (1) abandonment following removal of timber values, (2) inefficient administration of the tax system, and (3) inequitable taxes. Remedies lie in improving the opportunities for private forestry by adoption of more conservative cutting practices, improving the administration of tax laws, and in some cases revising the laws. For lands where private forestry is not feasible, some form of public ownership and administration is the obvious solution.

Recently the Station initiated another economic study, to ascertain and measure the factors influencing the adoption of sustained-yield forestry by wood-using industries. This study should reveal the physical and financial set-up most likely to succeed in the profitable employment of land, capital, and labor for sustained forest management and contrast it with set-ups that seems to work against these objectives. Out of this project should come a better understanding of the growing-stock requirements, the financial structure, the optimum size of utilization plant, and the type and extent of land ownership best suited to each of the principal forest sections in the South.

In the foregoing, I have discussed only those lines of research under way at the Southern Forest Experiment Station which are of major interest to southern lumbermen. I have barely touched upon several other research problems to which the Station is giving attention, such as naval stores investigations, studies of the relation of forests to streamflow and erosion, and flood control surveys. A summary of Station progress is issued currently in our annual report and in various occasional papers, releases, and notes. We are anxious to make these available to anyone interested in them, but present policy dictates that they be distributed only upon request.

In conclusion, I should like to suggest that you lumbermen avail yourselves more fully than you have in the past of the results of the Station's findings. Although we are not an extension agency, we are always glad to answer all reasonable requests for advice and assistance. Our experimental forests serve as demonstration centers, and you are cordially invited to visit them at any time. Many of you have already availed yourselves of this opportunity, and I trust have profited thereby.

We feel that research has already helped point the way toward better and more profitable forestry practice on private lands in the South, but we want to do much more than point the way. We want to orient our program so as to help you directly in your more complex and pressing technical forestry problems, to the very limit of such resources as we have available. We want not only to help solve the technical phases of such problems, but also to make our findings available for wide and effective application. To do all this we must have your help, in the form of constant contact and stimulation, of constructive criticism and suggestion, of moral support during the progress of our work, and of applying research findings in woods practices. We want you to feel that this is your Station, and that your problems and ours are mutual. With a combined attack on these problems, forestry in the South should make more rapid strides than it has heretofore, to the social and economic betterment of the region.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.

OCCASIONAL PAPER NO. 91

MAY 8, 1940

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New Orleans, La.

DISTRIBUTION AND SUGGESTED CONTROL MEASURES FOR THE SOUTHERN PINE FUSIFORM RUST

by

Howard Lamb, Assistant Conservationist and
Bailey Sleeth, Assistant Pathologist
Civilian Conservation Corps
Division of Forest Pathology, Bureau of Plant Industry,
in cooperation with the Southern Forest Experiment Station,
Forest Service, U.S. Department of Agriculture

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DISTRIBUTION AND SUGGESTED CONTROL MEASURES FOR THE SOUTHERN PINE FUSIFORM RUST[1]

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Control work on the fusiform rust canker disease of southern pine caused by the pine-oak rust fungus Cronartium fusiforme (A. and K.) Hedgc. and Hunt was initiated in 1937. A paper 2/ describing the disease and illustrated with photographs to aid in its recognition was released the same year. The present paper summarizes the situation as it is now known.

The common rust of slash pine (Pinus Caribaea Morel.) loblolly pine (P. taeda L.) and longleaf pine (P. palustris Mill.) is familiar to the woodsmen and foresters of the Gulf and South Atlantic States as elongated or spindle-shaped cankers on the branches and stems of seedlings, saplings and larger trees. The spherical type of canker caused by the closely related C. cerebrum Hedgc. and Long occurs infrequently in that part of the southern states in which the fusoid type of canker is common, and for this reason the latter is considered the typical canker occuring in the area and will be referred to in this paper as caused by C. fusiforme.

Susceptibility of pines and oaks to rust infection

It has been observed consistently that slash pine and loblolly pine are the two pines most susceptible to infection by C. fusiforme and in most areas where these two species were growing together, slash pine was apparently more susceptible than loblolly pine. Longleaf pine is relatively resistant to infection under most circumstances. Stands of longleaf pine with more than 10 percent of the trees infected have been reported infrequently, while in a majority of the stands examined less than 5 percent of the trees were infected. Shortleaf pine (P. echinata Mill.) which is commonly affected with the cerebroid type of canker is apparently highly resistant to infection by C. fusiforme for no fusiform cankers have been observed on this species.

The oaks range from very high to very low susceptiblity to infection by C. fusiforme as measured by telia production. As a group the black oaks are more susceptible to infection than the white oaks. Water oak (Quercus nigra L.), and willow oak (Q. phellos L.), are highly susceptible to rust infection and are considered to be the most abundant telia producers of the oaks. Other oaks in descending order of telia production are laurel oak (Q. laurifolia Michx.), blackjack oak (Q. marilandica Meunch.), blue-jack oak (Q. cinerea Michx.) and southern red oak (Q. rubra L.). Production of telia on turkey oak (Q. catesbaei Michx.) is relatively small. The white oaks have few if any telia. Q. alba L.,

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1/ Forest Pathology Contribution 40-17.

2/ Lamb, Howard. Rust canker diseases of southern pines. U.S.D.A. Forest Service, Southern Forest Experiment Station, Occasional Paper No. 72. December 27, 1937.

and Q. stellata Wang, are usually free of telia, although an occasional individual Q. alba tree may be found that has numerous telia. The live oak (Q. virginiana Miller) bears few if any telia, although information on its susceptibility to infection is meager.

Rust canker survey

Considerable time has been spent in conducting an extensive survey in the Gulf and South Atlantic States to determine the extent of the fusiform rust disease and damage resulting from infection in nurseries, plantation and stands of natural reproduction. The pertinent information gathered is given on a map, (Fig. 1)., which shows the approximate range of C. fusiforme and zones or extensive areas of heavy, medium and light infection based mainly on examination of slash and loblolly pine. The map is a composite of information on rust infection collected from nurseries, plantations and young stands of natural reproduction. The lines delimiting the various zones of infection should be considered as approximate and which may be changed with the accumulation of additional data.

The percentage of infected trees was found to range from less than 1 percent in some local areas in zone 3 to more than 80 percent in certain local areas in zone 1. Heaviest infection and losses were observed in southeast Louisiana, south Mississippi and south Alabama, zone 1, Fig. 1. Stands of slash and loblolly pine with less than 10 percent infection occasionally were found in zone 1, but most of the stands examined had from 20-50 percent of the trees infected and a few stands had as high as 80 percent of the trees infected. Infection of longleaf pine was higher in zone 1 than elsewhere, although seldom more than 10 percent of a stand were infected. Stands of slash and loblolly pine in zone 2 had a lower average percentage of rust infected trees than similar stands in zone 1. Infection in this zone ranged from less than 1 percent to as much as 50 percent in various stands examined while the average was between 5 and 30 percent with the more heavily infected stands in southern Georgia, northern Florida and southern South Carolina. Zone 3 is the most extensive of the three zones and includes an area west of the Mississippi River and the northern parts of the Gulf and South Atlantic States including a considerable portion of Florida. Rust infection in pine stands in this zone was usually less than 5 percent.

The presence of the rust disease in southern pine nurseries was first demonstrated in 1937. A survey made that year and in 1938 and 1939 revealed serious infections in several nurseries. Losses of nursery stock have been greatest in zone 1, where 15 to 35 percent of the slash pine seedlings in several nurseries were infected with rust. Although infection of longleaf pine seedlings has been less than that of slash pine, infections of 10 to 15 percent of the longleaf pine seedlings have occurred in several nurseries, and losses of 2 to 5 percent have been common. Rust infection has been less severe in nurseries located in zones 2 and 3 than in zone 1. Also the disease was much more severe in nurseries in 1938 and 1939 than in 1937; this was probably because conditions for pine seedling infection were less favorable in 1937 than in the following 2 years. However, with the increase in number of oaks in the South it is probable that the level of infection hazard has been on the increase in recent years.

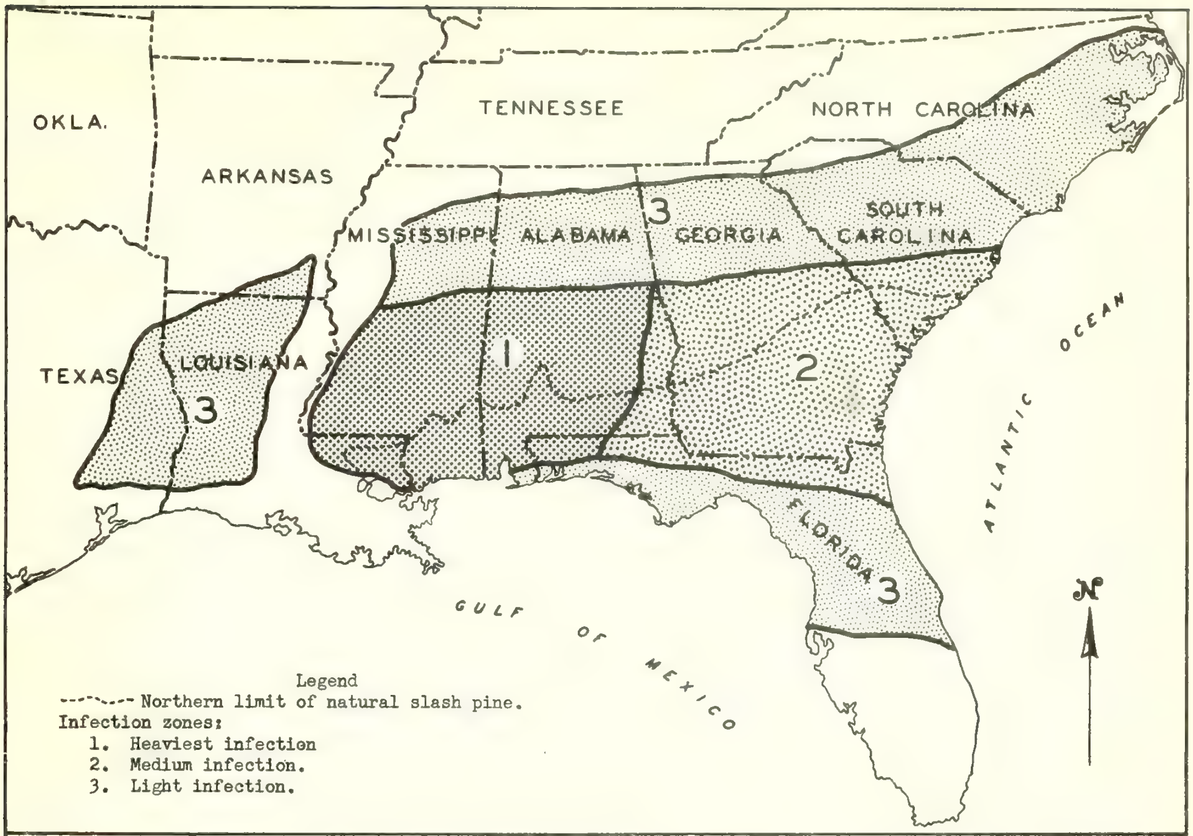

Figure 1. - Map showing range and infection intensity of fusiform rust disease of southern pines and approximate northern range of slash pine. The map is based mainly on information secured in 1938 and 1939 from plantations, natural reproduction and forest tree nurseries. Some changes may be expected to the zone boundaries as additional observations are made.

Damage caused by the rust canker disease

Mortality from rust infection is highest in the seedling stage and young stands and least in the mature stand. Seedlings infected in the nursery are considered a total loss because they will die within a few years if planted in the field. Young seedlings and saplings with trunk infections are either killed by the disease or so badly damaged as to become worthless, particularly slash pine. Older trees with trunk cankers may continue to live for a number of years after infection takes place, although the trunks may be seriously injured, such trees frequently seem to grow almost as well as uninfected ones nearby. However, trunk cankered trees frequently break over during storms. Trunk cankers are less serious on loblolly pine than on slash pine. Branch cankers that never reach the trunk are thought to cause little or no damage to the tree.

Losses in plantations and natural stands depend on many factors, such as age of stand, intensity of infection, number of trunk infections, and utilization and management practices. Losses that would be negligible or perhaps in some cases even beneficial in heavily stocked natural stands, are serious in plantations, where there are fewer trees per acre and the loss of a part of them would result in an understocked stand. It will be possible, in many instances, to salvage many infected trees for pulpwood when the stands are thinned or when improvement cuttings are made in this way losses attributable to rust may be reduced.

Plantation losses in slash and loblolly pine from rust in zone 1 and in parts of zone 2 could be reduced by substituting a more resistant species for slash pine. Where this means planting another, but less desirable species, or one more difficult to grow in the nursery and plant in the field, or one that will not survive as well in the field from causes other than rust, it may be better to continue planting the more susceptible species on the more suitable sites, even despite danger of losses from rust. Slash pine in plantations, outside its natural range, (Fig. 1) is usually more heavily infected with rust than neighboring stands of any of the native pines of comparable size and age. However, this apparent increase of susceptibility to infection over native pines is not sufficient to justify any reduction in the planting of slash pine in zone 3 or apparently parts of zone 2.

Control

Control of this rust disease depends for the most part on the prevention of infection in the nursery and the removal of cankered branches from young trees in the field before the infection extends to the trunks.

Eradication of oaks (the alternate hosts of the rust fungus) from the area about the nursery should reduce seedling infection. The cutting of infected pines or pruning cankered branches in the vicinity of the nursery along with oak eradication is of doubtful practical value, and yet it may have some sanitary value. At one nursery an oak-free zone 1500 ft. wide apparently reduced infection, but it did not provide complete protection. Elsewhere, nurseries with partially oak-free zones gave little or no indication of benefit. Because of the difficulty of checking the effectiveness of oak eradication definite conclusions cannot be made on the observations to date. Under most circumstances the removal of the more susceptible oaks near the nursery should help in reducing infection, but in most places sufficient protection to the nursery probably will not be secured to justify the cost of establishing an extensive oak-free zone unless the eradication can be combined with an utlization operation, such as one for saw logs, fire wood and posts, or where the oaks are relatively scarce in the vicinity.

From observations made in 1938 and from results obtained in several nurseries in 1939 it seems that a combination of late sowing and early and thorough spraying gives promise of controlling or greatly reducing rust infection in nursery stock. It has been demonstrated that rust infection in a given nursery is lower in beds of slash pine sown late than in beds of the same species sown earlier. Seeding should be as late as possible without endangering the production of plantable stock; each nurseryman will known the latest date that will permit economical production of good stock in his nursery. Where infection has been sufficient to warrant preventive measures, spraying should start as soon as the burlap or other cover is removed from the seedbeds or when the uredia appear in vicinity of nursery and should be continued until June 1, with at least one spray application each week. In nurseries where past experience indicates danger of heavy rust infection, it may be desirable to spray the burlap or other cover on the seedbeds at least once between the first emergence and the removal of the burlap or other cover. In such nurseries it will also be desirable to spray at intervals of 3-4 days (twice a week) for the first 3 weeks after the removal of the burlap. A 4-4-50 Bordeaux mixture, preferably homemade, with a good sticker and spreader added, is recommended as a spray. On a trial basis only, liquid lime sulfur 1-50 has been suggested in place of Bordeaux mixture. Liquid Santomerse used at the rate of 1 pint to 100 gallons of spray and a linseed oil and soap emulsion (6 lbs. of raw linseed oil and 6 lbs. of fish-oil emulsified in 6 pints of water to 100 gallons of spray), are the two most promising spreaders and stickers tried to date. Fish-oil soap or casein spreader may be used at the rate of 3 lbs. per 50 gallons of spray.

Spraying for rust control must be thorough, covering all portions of the seedlings. Power sprayers should be used when available, and the spray should be applied at the highest pressure that can be obtained safely with the sprayer used. Results secured in 1939 indicate that dust fungicides probably will not provide protection from rust infection.

Pruning infected branches before the cankers extend to the trunks may be used to reduce losses in plantations and natural stands. Most effective results can be obtained in young stands less than 10 ft. tall in which there are many branch infections that have not extended to the trunks. In stands of this type, all branches with cankers less than 24 inches from the stem should be removed, unless it is evident that the infection has already entered the trunk. At present, it is of doubtful advisability to remove or cut out young trees with stem infections, as they may live long enough to function as trainers in the stand and eventually reach pulpwood size. When older stands are thinned or utilization cuttings are made the trunk cankered trees should be removed. Pruning may be done with saws or pruning shears. All cuts should be made flush with the trunk or main branch. It will not be necessary to burn or otherwise destroy the pruned branches, because the fungus dies with the severed branch. Pruning may be done at anytime in the year. In very young stands, 3-6 ft. high, it may be advisable to delay pruning until winter or early spring. By late winter many infections of the previous season will have developed into noticeable cankers that may be easily recognized and removed.

The shipment of seedlings from nurseries in the zone of heavy rust infection to areas where there is little or no rust on the native pines is a questionable practice because of the danger of introducing new, and perhaps more virulent strains of the rust fungus into such areas. When pine seedlings are lifted and graded, rust cankered seedlings should be culled out so as to minimize the danger of disseminating rust strains and to prevent the planting of worthless and diseased stock. It is highly probable that some infected trees will be included in shipments of seedlings from nurseries where infection is heavy. Even the most of the nursery infected seedlings will die before the cankers produce spores, a small percentage may live long enough to allow the cankers to fruit and thus provide a source of infection of the native oaks with a different or new rust strain for that area. It is usually undesirable to ship nursery stock for long distances, but if such shipments must be made it would seem preferable to ship pine seedlings from areas of light rust infection into areas equally or more heavily infected rather than to ship from a heavily infected zone into a less heavily infected one. While it has not been demonstrated that differences exist between strains of the rust fungi, it is probable that they do, and it would be highly undesirable to introduce virulent strains of the fungus into areas where there has been little or no loss from this disease.

Further information on this disease may be obtained from the Bureau of Plant Industry, Division of Forest Pathology, Southern Forest Experiment Station, New Orleans, La.

OCCASIONAL PAPER NO. 92

JUNE 20, 1940

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THE FOREST TAX DELINQUENCY PROBLEM IN THE SOUTH

By

Ronald B. Craig,
Associate Forest Economist,
Southern Forest Experiment Station.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

THE FOREST TAX DELINQUENCY PROBLEM IN THE SOUTH[1]

By

Ronald B. Craig,
Associate Forest Economist,
Southern Forest Experiment Station.

Recent literature (7, 20, p. 870)[2] on the nonpayment of the property tax lists the South with the Lake States and the Pacific Northwest as the three regions of the nation suffering most severely from forest tax delinquency. The statement is valid, if by it the authors mean that a considerable percentage of the taxes currently levied on forest land become delinquent annually, and in some cases are never paid at all. While accurate data do not exist, there is evidence that possibly 22,000,000 acres of rural land (forest and non-forest) in the eight states from Georgia and Florida to eastern Oklahoma and Texas are now in default of tax payments for two or more years. This is 10 percent of the gross land area under consideration (228,033,000 acres).

Such a condition poses a problem in governmental finance, in land utilization, and, most important, in the economic stability and welfare of the citizens of the South. Unfortunately, however, there has been much loose thinking and writing concerning tax delinquency, the problems created by it, and their solution. No small part of this lack of clarity has been created by the confusion in terminology used in describing the varying conditions of "tax delinquency." Too often the general term has been used to describe any nonpayment of taxes from temporary delinquency of those currently due to complete forfeiture of title to the public. Hence any clear discussion of the subject must first define the terms used, and indicate the general tax collection procedure in use in several Southern States.[3]

I

The laws of each of these states require that the taxes levied by it or its political subdivisions be paid before a definite date. Taxes unpaid on that date are "delinquent." Tax delinquency begins, therefore, on some legally established date generally known as the "delinquency date" or "penalty date." In all of these states except Florida and Louisiana, provision is made for paying state and county taxes in two to four installments, and in general the delinquency date is the final due date of each installment. If taxes due are unpaid on this date, a penalty (a flat percentage of the taxes, of interest, or both) is charged the taxpayer (in Georgia and Florida no penalty or interest is applied). It is at once evident that there are two distinct types of delinquency, "short-term" and "long-term." The former has been defined as "that type of delinquency which exists when a tax has not been paid at the end of the legal collecting period, and becomes subject to a penalty." "Long-term" delinquency has been defined as "that type of delinquency which exists when taxes are due for two or more years and the taxpayer is in danger of losing his property" (12, p. 185) through foreclosure of the tax lien. Obviously, short-term delinquency may grow into long-term, but in many cases it is merely a temporary condition of not very serious import.

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[1] Reprinted from The Southern Economic Journal. Vol. VI, No. 2, October, 1939.

[2] Figures in parentheses refer to list of literature cited at end of this paper.

[3] Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, eastern Oklahoma, eastern Texas.

In the states here considered a "tax sale" is held from one to eight and one-half months after the due date of the last installment. At the tax sale, the tax lien is offered for sale to the highest bidder who must bid at least the amount of the taxes due, plus penalty and costs. If no such bid is received, the lien is held by the state (or county in Georgia and Oklahoma), subject to redemption by the original owner, his heirs, or assignees. If the tax lien is purchased by a private buyer, he also holds it subject to the original owner's right of redemption. This "redemption period" exists from one to three years from date of tax sale (Alabama, three years; Georgia and Louisiana, one year; other states, two years). In Alabama and Louisiana, however, the owner can redeem his property from the state (though not from private buyers) at any time prior to passing of title from the state by tax deed to a third party.

The ultimate step contemplated in the enforcement of tax collection is the final sale of the property to satisfy the debt. This takes place at the end of the redemption period, the process varying among the states and between private and public holders of the tax liens. At this time, the private holder of a tax lien can apply for a "tax deed" vesting him with perfect title (under certain conditions) to the property. Where the lien is held by the state or county, the law contemplates that certain steps will be taken to vest similar title in the governmental unit. Only in Florida and Texas, however, do these steps include a legal suit to foreclose the lien (and even in these states the suit is seldom entered). All that is required in Arkansas, Louisiana, and Mississippi, is that the proper county official certify to the state that the property has been delinquent for the length of the redemption period, that due notice has been given of its pending forfeiture, that it has not been redeemed, and is thereby forfeited to the state in "fee simple forever." In Oklahoma, if the property has not been redeemed by April of the third year following tax sale, it is offered to the highest bidder at a resale and if not then sold, it is deeded in fee to the county. In Alabama, forfeiture to the state is ipso facto, i.e., no special procedure is required. In Georgia, the county may assume title after due notice to the owner.

Property so vested is said to be "forfeited to public ownership," "reverted," "certified," or "adjudicated." Tax-forfeited land held by the state or county is subject to sale by it to any applicant except the original owner, his heirs, or assignees; in Mississippi, however, the original owner can purchase his own property. Alabama, Arkansas, Mississippi, and Texas have provisions in their statutes for the setting aside and administering of suitable tax-forfeited land held by the state as State Forests. It is obviously the land vested finally in public ownership—"reverted" land—that constitutes the greatest problem. It is this land that is sometimes referred to as "new public domain" and which, when covering large areas, creates a burden on government and non-delinquent taxpayers alike.

This discussion of the provisions for tax collection enforcement has necessarily omitted many local details, and as will be pointed out later, practice is usually widely divorced from the laws here summarized. Indeed, such failure to follow the law is one of the chief causes of the growth of long-term tax delinquency in these states, a growth which has reached alarming proportions.

II

The safest statement which can be made relative to the area of any state or region which is "tax-delinquent," or "in public ownership for non-payment of taxes" is: "No one knows." The difficulty of obtaining any accurate data is compounded of the nature of the phenomenon itself, the lack of adequately kept public records, the confusion in terminology, and the rapidity of change in the status of such areas. In many estimates from all sources, however, short-term and long-term delinquency have been confused and added together to give highly alarming pictures of tens of millions of acres of rural land "forfeited to public ownership," when actually the area so forfeited in a legally indefeasible title was very much less.

Tax delinquency, which is one of the least static of fiscal conditions, varies not only from day to day with the flow of land into and out of a delinquent status, but much more with the seasonal relation of the time of taking data to the delinquency date, the foreclosure date, and other administrative periods. None of these eight states keeps an accurate and up-to-date record of the area held by it through tax-forfeiture, and even local county records are rarely accurate and current. Reasonably accurate data, as of given dates, are available for a few states, notably Mississippi (January 1, 1936) (15) and Arkansas (January 1, 1934) (3) and, slightly less accurate, for Louisiana (November 1, 1934) (unpublished data). Data are available for Florida only as to the area covered by all outstanding tax certificates, i.e., for lands involved in both short-term and long-term delinquency, as of January 1, 1934 (21). In other states, approximations of all land involved in any delinquency are available but not authenticated, and in certain scattered counties accurate data are available on land actually forfeited to public title or legally eligible for such forfeiture. Based on all these admittedly incomplete and not always comparable data, it is estimated that in the eight states here considered the area as of date delinquent beyond the legally established redemption period and therefore subject to final forfeiture to public title (whether or not this final step has been taken) may be in the vicinity of 22,000,000 acres. No accurate figures can be given for the individual states, but, on the basis noted above, the rank of the states, in decreasing order of area delinquent, appears to be as follows: Florida, Georgia, Louisiana, Arkansas, eastern Oklahoma, eastern Texas, Mississippi, and Alabama.

It must be realized, however, that if there are 22,000,000 acres in the tax status just described, it does not follow that this area is fully vested in public ownership with a clear and sound title. Indeed, it may be questioned whether any but a small fraction of this vast area is so vested. The titles to most of the properties included in this tax-delinquent "no-man's-land" are "suspended somewhere between the original owners and the Government, neither the former nor the latter having valid title" (1).

It is as true in the South as elsewhere in the nation that forest land comprises more than half of this tax-forfeited area. The greater susceptibility of forest land to delinquency has been noted in all parts of the country by Zon (22), Sparhawk (18), and others, and in the South the writer has found it true in several states (9, 10, 11). No accurate data exist except for scattered counties, but it is safe to assume that, of the 22,000,000 acres noted above, between 13,000,000 and 15,000,000 acres are forest land. The reasons for the larger percentage of forest land than of agricultural land involved in long-term delinquency will be discussed in the next section.

III

It will be obvious that the immediate causes of individual failure to pay taxes when due are many and varied. There are, however, certain broad groups of causal factors common to the situation in all of the states here considered and in many other parts of the country. It should be realized, also, that the causes of short-term and of long-term delinquency may not be the same. It is true that short-term delinquency may become long-term because (a) once the process is started, the taxpayer finds it harder to get back on his feet and often fails to do so, and (b) public officials find it harder to collect back taxes than current ones. It is evident, however, that long-term delinquency has its roots in more fundamental and deep-seated causes, many of which operate regardless of the use of the land and cause delinquency of crop and forest land alike. First, however, let us consider the causes of short-term default.

There is a remarkable unanimity of opinion among investigators of tax delinquency in respect to the principal cause of short-term delinquency. Fairchild and his associates of the Forest Taxation Inquiry of the United States Forest Service state: "The evidence is fairly conclusive that much short-term delinquency is due to a faulty collection practice" (12, p. 189). The National Tax Association's Committee on Tax Delinquency makes an identical statement (17). Coming to the South, Willis found in Florida that "the numerous and continuing attempts to favor delinquent taxpayers . . . have encouraged nonpayment of taxes" (21, p. 117). Fullilove in Georgia (13), Gabbard in Texas (14), Henderson in Mississippi (15), Brannen in Arkansas (3), and the writer in several states (7, 8), all came to the same conclusion. The "faulty collection practice" referred to may be in the law itself: a penalty for delinquency too light or too severe or none at all, lack of relation between the collection date and the period of income of taxpayers, local authority for waiving or rebating of penalties and interest—all tending to encourage delay in payment or outright evasion. More often, however, it is in failure on the part of county officials properly to enforce the law. "The laxity of enforcement is largely a product of a system of popularly elected collectors" (17). Such failures in the law or its administration or both are obviously "grossly unfair to those who pay their taxes promptly and without coercion, and are of doubtful benefit to those they pretend to help" (12, p. 189).

Certainly since 1930, another major cause of short-term default has been the depression. Failure of markets for the products of crop, pasture, and forest land, declining prices, tightening of credit facilities, all contributed to the inability of landowners to get sufficient income to meet their obligations. The tax collector frequently was the first to be put off when the pinch of hard times came. This fact is amply proved by data on trends in current tax delinquency from 1928 to 1933 (19), which show the rapid increase in short-term default following 1930. Later scattered data indicate that following the business upturn in 1936, rural delinquency decreased rather sharply from the depression peak.

While faulty collection practices also contribute, sometimes materially, to long-term delinquency, there are generally deeper and more fundamental causes of this more serious phase of tax default. Here again a large degree of uniformity of opinion as to the causes is found among investigators. The Forest Taxation Inquiry states: "The chief cause of long-term tax delinquency is overassessment. A property owner will rarely find it necessary to surrender title to his property unless the taxes threaten to absorb all or a major part of the expected future income therefrom. . . .The tax on a particular piece of property is not likely to be confiscatory unless the property is assessed at more than its true value" (12, p. 189). The National Tax Association finds that, among the four factors involved in "the full solution of the problem of tax delinquency," the first is "such revision of the whole tax system as is necessary to harmonize benefit and ability as bases of taxation, with each measure of ability given its proper weight" (17). In Florida, Willis lists "incorrect assessment" as one of the three principal causes of extensive tax delinquency (21). Gabbard found in Texas: "Faulty assessment, resulting specifically in disparity of assessment, overassessment, and failure to assess, is one of the primary causes of delinquency" (14).

There can be no doubt of the fact of overassessment of forest land in the South. Whether or not the original owners sinned against society in following clear-cutting practices in the exploitation of their forest properties, the fact remains that the cut-over land is generally grossly overassessed in relation to crop land or mineral land in the same counties, as is evidenced by the relative assessment ratios and tax ratios. This is one, if not the chief, reason why forest land forms such a high percentage of the total tax-forfeited area of the South.

Another cause of long-term delinquency—a possible corollary of overassessment, since it frequently results in such disparity—is the decline in property values. In the South there is abundant confirmatory evidence to be found in Florida, in Oklahoma, and in other states. The collapse of the 1924-26 real estate "boom" in Florida left thousands of acres with rapidly shrinking values and diminishing prospects of future income, but saddled with debt-service taxes, which, on the inflated values, were possibly within reason but which, on the declining values in the aftermath of the boom, were plainly confiscatory. Hence arose, in large measure, Florida's vast area of long-term delinquent land, now indeed a "no-man's-land" with the titles suspended amid a conflict of the thinnest of claims. The writer, in a recent investigation in certain Oklahoma counties, particularly those suffering from the after-effects of a recent oil boom, found a similar relation between declining values and increasing delinquency (10).

A third cause of long-term default is the increasing portion of property income required for taxes. The need for increased revenue to finance the constantly expanding services demanded of government has resulted in increased assessments or, more frequently, higher tax rates, and hence in higher tax ratios—the relation of the taxes levied on property to the net income from it, before tax payment. This has been an important cause of delinquency in parts of the South, especially of cut-over forest land. In parts of west Louisiana, throughout Florida (although in this state special assessments as well as assessments for ordinary governmental operation are involved), and in certain counties of other states, tax rates have risen to such heights that when applied to the existing assessments the resulting taxes have plainly threatened the possibility of any future returns from the ownership of property (6).

Still another cause of delinquency leading to loss of title is the levying of an intolerable burden of special improvement-district taxes. The levee and drainage districts of the great Mississippi River Delta in Arkansas, Mississippi, and Louisiana, and the special drainage and other districts in Florida, are eloquent witnesses to the futility of saddling excessive bonded debt on rural or urban land. A recent study in the Yazoo Delta in Mississippi showed clearly that these special improvement-district taxes were the primary cause of tax default in this area (9).

These are the fundamental and deep-seated causes of long-term delinquency. There are, of course, other causes that stem in part from those just discussed. These include improper or unwise land utilization, overexploitation of natural resources, especially of the timber resource (not infrequently caused, however, by overassessment or excessive taxation of the original stand or of the land on which it stood), and, of course, personal and individual causes such as death of the owner, unexpected heavy expenditures for personal or family requirements, and unwise investments. Underlying these economic and personal causes, and closely related to the governmental ones, is the low level of the purchasing power of the predominantly agrarian South, which is reflected in the present inability of the region to consume directly, or to export to advantage, all the products the land can produce. This inability, in turn, results in a pressure, not of population on land, but of land on population, and may contribute materially to tax delinquency. All of these causes—statutory, administrative, economic, and personal—have been made more effective, of course, by the recent depression, which has narrowed the gap between income from property and the taxes required for the increased needs of government.

IV

The problems created by excessive delinquency, especially by long-term delinquency, may also be divided into three categories—governmental, economic, and sociological. All the effects, in whatever category, are so closely interrelated that overcoming them in only one of these groups without solving the problems in the other two will be of little permanent value.

It has been pointed out by many investigators that "tax default nurtures further default" (18). This is one of the most serious effects of the nonpayment of taxes, since it not only perpetuates the process but also increases the rapidity with which it grows.

The decline in the local tax base caused by removal from the tax roll of the assessed values of delinquent property—and hence decreased tax revenue—confronts government officials with four unpopular alternatives: (1) to increase the assessment or the tax rate or both; (2) to curtail public services to the citizens; (3) to depend on state subsidy; or (4) to consolidate into larger units. Resort to the first alternative may actually result in further decrease in revenue by engendering further delinquency. Resort to the second may mean political reprisals at the next election, since political history is replete with evidence of the unpopularity of taking away from citizens the public largess to which they have become accustomed. It can be done, however, and often is the only way out. Adoption of the third alternative is impractical, since it is generally admitted that the state should not subsidize indefinitely a county with an inadequate or unsound economic basis. The fourth alternative, while highly desirable, is the most difficult of all to adopt successfully. Local pressure against county consolidation, thereby threatening not only the "jobs" at the county courthouse but quite possibly the chief source of income for local merchants and hostelries at the abandoned county-seat, is a potent obstacle to this solution.

This dilemma of declining tax base and tax revenues is particularly difficult for the smaller units of local government, especially for school and road districts, many of which have outstanding bond obligations that must be paid if credit is to be maintained.

Still another effect in the governmental field is the engendering in public officials of continued or increased laxity in enforcing collection. They quite obviously tend toward leniency or outright negligence in the collection of delinquent taxes when they find it difficult to collect those currently due. This in turn leads what may have been short-term delinquency into a status of forfeiture and loss of title, thereby intensifying the difficulties of solution for both the government and the remaining nondelinquent taxpayers. If this process is carried forward without relief from the difficulties it breeds, the inevitable ultimate result is local government bankruptcy.

Even though bankruptcy is long delayed or even averted, there are economic effects of excessive delinquency no less disturbing than the effects on government. One of the first of these—even of short-term default-- is increasing neglect of a property by its owner. Fearing that he may shortly lose title to it, he is unwilling—or financially unable if he is to save enough cash to pay his taxes—to spend the money required to keep up the fences, paint his house, protect his woodland from fire, or improve his crop land. During such times also, he lends a willing ear to the operator of the nearest portable sawmill, who offers him a "rock-bottom" and "lump-sum" price for his timber on the stump and then cuts it clean, often paying the owner only a fraction of the actual worth of his timber. Such neglect and forced liquidation of property leads very frequently to loss of all income-producing capacity in the property, to ultimate loss of title, and to a condition vividly described by Zon as applicable to reverted land in the Lake States: "This land now comes back into public ownership stripped of its valuable timber, ravished by repeated forest fires, depleted of its fertility, and often disfigured by gullies due to erosion. . . .It is not welcomed either by the State or county and is poorly protected against fire and trespass. . . .Like an abandoned child, it is left on the steps of the county courthouses or state capitols to be disposed of in the best way possible" (22). While such a description may paint too black a picture to be true of all reverted forest land, there is abundant evidence that the difference between such land in the Lake States and its counterpart in the South is one of degree rather than of kind. Indeed, there are areas in the South where even the difference in degree is negligible. Much the same statement could be made in respect to reverted crop and pasture land, particularly as to erosion damage.

Declining private income from property, increasing tax costs on the nondelinquent land or, in lieu thereof, decreased public services to remaining taxpayers, increasing land abandonment—all stemming from chronic tax delinquency—lead inevitably to lowered standards of living, to more and more shifts from owner-operation to tenancy, to greater and greater public "relief loads." The ultimate picture is well painted by Sparhawk: "Carried far enough, this process discourages or even renders impossible the occupation and profitable use of the remaining privately-owned land in the locality. In extreme cases, whole sections of counties or states may then be virtually depopulated. If any people remain, they constitute pauper communities which look to the State or federal government for funds with which to carry on the ordinary functions of government" (18).

The areas in the South which are seriously involved in social deterioration arising through long-term tax delinquency are fortunately few, but they can be found in greater or less degree in nearly every state of this region in which such tax delinquency involves any considerable area. What, then, are the steps toward a solution of this whole problem?

V

There can be no doubt that too much effort has been spent in the past in evolving methods of handling and using lands which have already reverted to public ownership in comparison with the effort made to prevent, or decrease the volume of, future delinquency and reversion. It will serve public and private interests little to evolve complicated machinery for determining the best use, ownership, and administration of reverted lands when the volume of the annual flow of private property into public title under existing conditions exceeds by far the area which the public can afford to handle and use. Nevertheless, much of the literature on this problem is concerned more with what to do about it after it has arisen than with means of alleviating its causes. Since the chief causes of both short-term and long-term delinquency lie in the field of governmental organization and administration, it is obvious that the first attack on the problem, whether relating to crop land or forest land, must be on that front.

The previous discussion of the causes of delinquency has necessarily hinted at some of the steps toward preventing or decreasing this process, and a full discussion of the steps required to solve all the problems involved in these lapses in governmental perfection is far beyond the scope of this paper, but they may be summarized as follows: (1) improvement in the whole assessment system and practice to relate benefits received by, and taxpaying ability of, property to its assessment; (2) improvement in supervising by the state of local finances, and in relating the extent of local governmental services to the local tax base, present and potential; (3) prompt, impartial, and equitable enforcement of properly drawn and reasonable tax laws; and (4) such changes in the organization of political units and in the distribution of functions as are calculated to insure the greatest efficiency (2). When these steps have been taken, much of the problem of delinquency will have been solved, because the causes mentioned above will have been largely eradicated.

It is obvious that this, the most important step toward a solution, is chiefly the responsibility of the state and local governments, with such aid and advice as may be required from federal agencies or private sources. More directly and ultimately, perhaps, it is the responsibility of the taxpayers themselves in the exercise of their citizenship in the state.

There are also, as has been shown, economic and personal causes of long-term delinquency—unwise land utilization, overexploitation of natural resources, private inefficiency in management and administration of property. To solve these problems the government and its citizens must also work together. The areas of land utilized unwisely should be found by studies of soil potentialities, economic demand for products, and margins of costs and returns, and the results should be made available to all citizens. Owners of timberland or other renewable natural resources should be protected against confiscatory taxation of their property in order to make it possible for them to exploit the resource permanently and profitably; they should be aided by such extension services as will show them how to administer their properties to this end; and they should themselves recognize the obligations imposed by the private ownership of resources in which all the people have a "vested" interest.

An important aid in the solution of the problems involved in the economic causes of delinquency is the development of a sound but flexible, state-wide but detailed, plan of land-use. To this end the State Planning Boards of several of the Gulf States are now working. It is no easy task, and if it is to be effective the plan must have great flexibility. It must be administered with the stress on popular education to its provisions, but nevertheless it must have teeth for use in case of necessity. Rural zoning is advisable only on the basis of some such state or local plan of land-use, but such a plan is not a cure-all for delinquency; rather is it a guide to sound utilization of the soil and its resources.

Finally, there are personal responsibilities, other than those enumerated above, involved in any alleviation or prevention of further delinquency. Not the least of these is the recognition that private ownership of property imposes duties as well as grants privileges. Allen states: "In view of the relationship between private property and government, it is obvious that the property owner is liable for the payment of lawful taxes. Property, unless specifically exempted, is owned subject to the payment of taxes. Government could not survive and perform its functions if this were not true" (1). It has also been well said that "Good government is costly government" (16), by which the author meant that government cannot be operated efficiently along modern lines with only "shoestring" revenues such as are available to many local governments today, particularly to those in the rural South.

Thus far we have discussed the first, and most important, part of the solution of tax delinquency—its prevention. There still remains the problem of disposing to the best advantage the area already in, or about to revert to, public ownership through tax default. There are two schools of thought in respect to its solution. It is recognized by all, however, that the first problem is one involving a judicial clarification of tax titles now "suspended somewhere between the original owners and the government." Obviously, neither government nor a private person can afford to incur expenses for administering and developing property to which, at best, it or he has but a shadow of title. Even a supposedly bona fide tax deed frequently conveys little better than a clouded title. Hence means must be found to vest a clear title either in the original owner of such property or in the purchaser of the tax lien (whether government or private person). This is an extremely difficult task. In cases where such delinquency resulted from gross overassessment, it may be necessary to revise the tax debt by lowering the original assessment to an equitable figure and recomputing the taxes. Installment payment of delinquent taxes may be provided (already possible in Louisiana, by paying 10 annual installments with interest at 6 percent). Possibly, penalties on such delinquency (in the "suspended title" status) could be waived if all back taxes and interest were paid up promptly, or if a binding agreement for installment payment were made. On all properties on which the original owners refused or neglected to adopt any such compromise and which were not clearly vested in private purchasers of the tax liens, the state or county should promptly and permanently foreclose its lien and vest perfect title in itself, by a suit entered in a court of competent jurisdiction.

Having now established the land which cannot be restored to the original owners, and to which government has a perfect title, the next step should be use classification. State and local experts in land classification and land values in each county should appraise this land, and classify it as to its potentialities for profitable private or public use. Land classified as best adapted to private ownership and use should then be offered for sale at the appraised value set by the local-state agency. Possibly the state should demand, as a guarantee against further unwise use or overexploitation, some modicum of control over the immediate operation of the property; it should always do so if the purchaser buys it on an installment basis. Land adjudged best suited for public use should be held by the government, and its administration and development assigned to that division or agency having statutory jurisdiction over the particular use to which the property is to be put.

Such a plan is believed best suited to our democratic American pattern, although there are advocates of much more stringent action on the part of government. Thus Sparhawk, possibly basing his opinion on the type of denuded and reverted forest land referred to by Zon in the Lake States, says: "Certain conclusions are inescapably drawn from the public-domain studies so far made . . . . Forest land now in public ownership [through tax-forfeiture] should be retained in such ownership and administered in the public interest" (18). Zon himself, seven years earlier, had declared: "The State will have to come to a comprehensive program of reforestation and recreational development of this newly acquired Public Domain . . . . No other solution seems in sight at present" (22).

On the other hand, there are advocates of a strictly private handling of reverted forest lands, or an attitude of complete laissez-faire in regard to them. Bunker states: "In considering the tax burden as the cause of forfeiture of lands to the State, it is well to observe that the losses to the Commonwealth through unprofitable attempts to operate these areas as [State] forests may easily exceed the lack of tax revenue, especially in view of the fact . . . . that the apparent deficit in taxes is largely compensated for by the increased burden placed on other property" (4).

The solution first suggested seeks to follow a middle course between the extremities of complete public control on the one side and private or no control on the other, "on the basis that, as in all other important problems of society, there is a normal balance between public and private activities, between personal profit and common good, and that only by maintaining this equilibrium can the highest good be secured" (5).

VI

Various agencies of the federal government also have an interest in the solution of this problem. Space does not permit a discussion of the relation of all these agencies to such solution, but since more forest land is involved in delinquency than land in other uses, the United States Forest Service has a keen interest, and hence a particular responsibility, in solving this problem. This responsibility it seeks to discharge in several ways.

Obviously, the Forest Service can never do more than advise in connection with the overhauling, reorganizing, and increasing of efficiency of local or state governments. Through its Divisions of Research and of State and Private Forestry, it aids such governments, at their request, in devising means and methods for the more equitable assessment and taxation of forest land and timber. This may well be an important part of the requisite improved administration of taxation, since forest land forms so large a portion of the delinquent area. In such assistance, the Forest Service frequently points out specific changes in organization and administration of the government which will lead to an improvement of the whole technique of tax administration.

Since overexploitation of timber resources is one important "economic" cause of tax delinquency, the Forest Service contributes materially to a solution of this particular problem through its research into profitable methods of permanent operation of timber stands, and through its extension service to timber owners, bringing them the results of its research and of its experience as administrator of the National Forests. This contribution is perhaps the greatest one the Service can make to the solution of tax delinquency of forest land.

In the administration of delinquent forest lands and of abandoned farm lands, the Forest Service also plays a part through the acquisition, with local consent, of large areas of such lands as National Forests. A considerable part of the recent national forest acquisition in the South has been of this type, thereby assuring not only the protection and building up of these lands but also the paying up of all the delinquent taxes on such lands not fully reverted in fee to the state, i.e., those temporarily delinquent or forfeited. Furthermore, the federal government returns to the counties 25 percent of the annual gross proceeds from operation of the forest, and carries some of the costs of roads, fire protection, and similar items previously borne by the local governments.

Another contribution toward development and use of forest lands in which the Forest Service can aid the state governments is the acquisition of such lands under the terms of the Fulmer Act (Public No. 395, 74th Congress), whenever this act is implemented by the appropriation authorized in it. This act contemplates that federal funds will be made available for purchase of suitable forest lands, that the areas so acquired will be turned back to the states as State Forests, and that the states will reimburse the federal government for such financial assistance, without interest, out of the proceeds from these State Forests. The Forest Service is prepared to assist the states in bringing their statutes into conformity with the requirements of the Fulmer Act (Alabama, Arkansas, Mississippi, and Texas are the only Gulf States that have statutes fully complying with this act[4]) and in making surveys of the extent and character of tax delinquency. It is also prepared to assist them in the actual location and establishment of "Fulmer Act Forests" as soon as Congress makes available the requisite appropriation.

In one other field—and a most important one—the Forest Service also contributes to better forest protection and management, and hence to a decrease in forest-land delinquency. This contribution is through the provisions of the Clarke-McNary Law of 1924, as amended, whereby federal funds are made available, when matched by state and private funds, for the establishment of fire protection units on private lands; the average private contribution is 2 to 5 cents per acre per year. Another provision of this law authorizes the studies now carried on by the Forest Taxation Inquiry, previously referred to.

Thus in many ways the United States Forest Service is contributing to a solution of the problems of forest-land tax delinquency, and stands ready to continue its efforts and assistance in this work within the limits of its available funds. The Division of Research maintains its headquarters for the eight states here considered at the Southern Forest Experiment Station in New Orleans, whereas the administrative branch has its headquarters for the eleven states of the Southern Region under the Regional Forester, at Atlanta.

The evidence presented in this paper indicates both the size and the seriousness of the problem of forest-land tax delinquency in the South. It is believed, however, that the problem can be solved by the federal, state, and local governments in cooperation with the forest land owners and the forest products industries. Such efforts are already under way in several states, but need to be amplified and extended in order that all lands suitable for private development may continue in such use, while other lands may be devoted to those public uses for which they are best adapted.

In conclusion, it needs again to be emphasized, however, that "Tax delinquency which advances to the point where titles are surrendered on a large scale is prima facie evidence of serious economic or political maladjustments, and there can be no adequate solution of the problem apart from important—perhaps drastic—changes in the organization and financing of local government" (12, p. 197). Only so can long-term delinquency be decreased. All other steps are merely temporary palliatives, not permanent cures.

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[4] Information supplied by Regional Forester, Region 8, U. S. Forest Service, Atlanta, Georgia, January, 1939.

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Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration Official Project 65-2-64-74.

OCCASIONAL PAPER NO. 93 OCTOBER 22, 1940

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IMPROVEMENT CUTTINGS IN THE BOTTOMLAND HARDWOOD FORESTS OF MISSISSIPPI

By

J. A. Putnam, Associate Forester,
and
Henry Bull, Silviculturist
Southern Forest Experiment Station

In cooperation with
DELTA EXPERIMENT STATION, Stoneville, Miss.

The major portion of this study was carried on in cooperation with the Mississippi Agricultural Experiment Station under the Cooperative Farm Forestry Act of 1937. An unrevised form of this paper was mimeographed as an Advance Copy, dated August 10, 1940.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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The Need for Improvement Cuttings

Forty percent of the Yazoo-Mississippi Delta is forest land, a total of about 1.75 million acres. Most of this forest land is well covered with tree growth, but a large proportion of the trees have little or no economic value, either present or prospective. Like a cottonfield choked with brush and weeds, a forest containing many inferior, unprofitable trees cannot produce valuable crops until the inferior material is removed. The removal of inferior trees is called an improvement cutting and constitutes a very important part of practical forestry or forest management.

It is a common misconception that forestry consists largely of planting trees, or reforestation. In some forest regions the planting of trees is of major importance, but in the Delta comparatively little forest land requires planting. The Delta has very great need for improvement cuttings, however, since the second-growth forests growing up amid the remnants of the original forests, without any management or protection, leave much to be desired. The benefits to be derived from improvement cuttings are so great that it will pay every owner and manager of forest land in the Delta to acquaint himself with the principles and how to apply them, even if only in the cutting of fuel wood for the plantation. This paper contains recommendations for improvement cuttings based on the objective of maximum profit from wood products alone. In some cases it may be desirable to preserve shelter and food for wildlife by refraining from cutting trees that should be removed from the standpoint of timber management alone.

Improvement cuttings are especially needed in bottomland hardwoods because of the great variety of tree species and the great differences in the values not only of the various species but also of different trees of the same species. Some species are exceedingly valuable, others almost or entirely worthless. Individual trees of the same species, moreover, often vary in quality and value even more than do different species. Hardwoods of the same species vary in form from almost perfect individuals with long, straight, clear trunks to crooked, forked, widespreading "wolf trees," hardly worth cutting even for fuel wood, but occupying several times the normal growing space of trees their size and suppressing more promising neighbors. This same spread in value occurs even between well-formed individuals of the same species, because of variation in the quality of the trunk. Some trees yield almost perfect logs, while grubs or other insects, knots, bird peck, stain, ingrown bark, shake, or dote make the logs of other individuals of the same species useless for anything but fuel wood.

Commercial uses for Delta species place a high premium upon the cutting of choice trees and a penalty upon the cutting of poor ones. This accounts in large part for the high proportion of poor trees in the present stands. Delta species also are notably subject to fire injury and to subsequent decay that enters through fire scars.

About 20 percent of the trees in an average second-growth stand in the Delta are outright culls, while another 20 to 30 percent should be removed to facilitate the growth of better individuals already present, or to allow the seeding-in of promising new growth. In addition, there is usually 15 to 20 percent of the area that, due to overcutting and repeated burning, bears little or no established forest cover at all. Heavy grazing also is very detrimental in some localities. In view of this large aggregate proportion of the area (more than half) which usually needs reseeding and will reseed naturally after improvement cutting, with protection from fire and overgrazing, it is unfortunate that some of the poorer species, such as bitter pecan, overcup oak, and boxelder, are exceedingly prolific seeders. Special efforts, therefore, should be made in improvement cuttings to reduce the crop of undesirable seed and to maintain the supply and increase the proportion of desirable seed. After protection from fire, the outstanding needs in most Delta forests are the elimination of worthless individual trees, the reduction of the proportion of undesirable species, and the release of thrifty, desirable growing stock for optimum growth and development. These are the objectives of improvement cuttings.

Setting Up Cutting Standards

Many questions must be answered before improvement cuttings can be conducted with maximum efficiency and optimum results. Research in this field in the Delta was lacking until September 1939, when the Southern Forest Experiment Station, an agency of the U. S. Forest Service with headquarters in New Orleans, La., began a study at the Delta Experiment Station, Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station. The work was augmented in February 1940 through the establishment of a research project under the Cooperative Farm Forestry Act of 1937.

The study is being conducted on a 2580-acre tract of cut-over forest owned by the Delta Experiment Station and located only 2½ miles north of the station. The current improvement cutting experiment, which occupies 90 acres, will serve also as a demonstration of improvement cutting and soon will be readily accessible to interested visitors. A system of permanent signs and marks on representative trees in an uncut check plot will show which trees should be cut, which should be left, and explain why each marking was for "cut" or "leave." The results of applying the principles set forth can be inspected in adjacent improved plots. When the experimental and demonstration cuttings have been completed, a report on the volumes cut and left and on the returns from the operation will be issued. The specific directions given in this paper for making improvement cuttings were developed from the Stoneville study.

There are no hard and fast rules for making an improvement cutting. In general terms, the poor trees are cut and the good trees are left. "Poor" and "good" are such indefinite words, however, that at least a few specific cutting rules or recommendations must be used as a guide if the work is to be done logically, efficiently, and consistently. Specific cutting rules are given, therefore, in a later section. It should be thoroughly understood that their application is an art rather than a science.

Before stating the cutting rules or recommendations, the principles and tests on which they are based will be discussed briefly. There are five considerations that affect the decision whether or not to cut any given tree in an improvement cutting:

(1) Species
(2) Size
(3) Form and quality
(4) Vigor and thrift
(5) Position and space occupied

The practical use of these tests in making an improvement cutting may seem complex or difficult, but after a little experience it is actually rather simple. It frequently happens that a single glance at a tree shows that one consideration stands out above all the others, and that this alone is a sufficient basis for a decision as to whether to cut or to leave the tree. For example, the tree may be of such obviously low vigor and poor thrift as to be dying, or it may have passed its period of optimum development and show obvious signs of deterioration, or it may be more than half burned through at the butt and in danger of blowing over. All such trees that have any present value should be cut to salvage this value before death or further deterioration, regardless of other considerations. In other cases, two or three considerations taken together may stand out and make it unnecessary to look further. In brief, it is usually unnecessary to take up each test systematically or in order for each tree. It is usually possible to note one or two outstanding characteristics that in themselves are enough to determine the fate of the tree.

The five considerations will be taken up in order and discussed briefly:

(1) Species. There are at least two dozen separate species of trees in most bottomland hardwood forests, but these are best considered in only three groups in making improvement cuttings. In this paper the three classifications, "best," "intermediate," and "poorest," are based primarily upon commercial values. The common tree species of the Yazoo-Mississippi Delta are grouped as follows (see p. 14 for scientific names and other common names):

Poorest species (weeds)

- Boxelder
- Waterlocust
- Hawthorn
- Planertree
- Ironwood
- Swamp privet

Intermediate species

- Overcup oak
- White elm
- Rock elm
- Winged elm
- Hackberry
- Willow
- Red maple
- Sweet pecan
- Bitter pecan
- Hickories
- Honeylocust
- Sycamore
- Blackgum
- Swamp cottonwood

Best species

- Bottomland red oak
- Willow oak
- Water oak
- Cherrybark oak
- Cow oak
- Cottonwood
- White ash
- Green ash
- Redgum
- Persimmon
- Mulberry
- Cypress

Why the different species were classified in this way is best illustrated by a few examples. A bottomland red oak log is worth more than an elm log of the same size and quality; so bottomland red oak is considered a better species than elm. A bottomland red oak log and an overcup oak log of the same size and quality are of about equal value, but red oak is several times more likely than overcup to yield large, high-grade logs. The red oak also grows more rapidly than the overcup oak. Hence, there are at least two good reasons for considering red oak the better species.

The poorest species are merely "weeds" of little or no economic significance. They should be eliminated just as rapidly as practicable in order to provide space for more valuable species. Shrubs and vines also should be treated as weeds and cut if they are large and interfere with trees or reproduction of the best or intermediate species.

(2) Size. Only two size classes need be considered: Under-sawlog size, and sawlog size. The boundary between these two classes is set arbitrarily at 14 inches d.b.h. (diameter at breast height). Trees 14 inches and larger are considered to be sawlog size; smaller trees, under-sawlog size. Usually a good lower limit in an improvement cutting is 5 inches d.b.h., since smaller trees are generally unmerchantable and unusable, and their effect in the forest, even if undesirable, is relatively slight.

(3) Form and quality. This is especially important, but often hard to judge. Experience gained from seeing trees and logs cut up is invaluable, although not an infallible guide. The principles, however, are simple. The goal of management in the bottomland hardwoods is assumed to be the production of straight, high-quality logs, suitable in large sizes for industrial lumber and veneer, and in small sizes for cooperage, small-dimension stock, and specialties. These are the only logs for which there is ordinarily a profitable cash market, and they will be referred to hereafter as "high-grade" logs. A high-grade log is defined here as one which is at least 10 inches in diameter inside the bark at the small end, at least 12 feet long, straight enough to be handled as one piece, and with at least 60 percent of its surface

entirely clear of defects.[1] If a tree does not now contain at least one high-grade log, or will never develop one because of its poor form or low quality, it is not a desirable tree to retain since it does not satisfy the goal that has been set up. The terms "at least one high-grade log" and "at least one actual or potential high-grade log" therefore are used frequently in the cutting rules. They are convenient terms for describing briefly a minimum quality. The requirements are easily memorized and trees meeting them are readily recognized in the woods, subject to differences of opinion as to the presence and extent of defects.

Helpful information on how to recognize the presence and extent of defects in bottomland hardwoods is almost impossible to furnish on paper without the aid of good photographs. Such pictures are not yet available and the present discussion of defects will therefore be confined to the brief tabulation of the more important kinds of defect, on page 6. This will be useful even if it only calls attention to some defects that might not otherwise be considered at all.

(4) Vigor and thrift. From the standpoint of vigor and thrift, there are two classes of trees that always should be removed in an improvement cutting. These are (a) "poor risks," and (b) overmature trees.

A "poor risk" is a tree, containing merchantable or useful material, that is unlikely to remain alive until the next time a cutting is made. If no other cutting is definitely scheduled, this period should be assumed to be 5 to 10 years. There are many reasons why a tree may soon die and most of these are obvious at a glance. The tree may be leaning badly or deeply fire-scarred at the butt, hence likely to blow over. It may have a dead top, dying branches, and scanty, unhealthy foliage. It may be seriously suppressed by neighboring trees, with no growing space and only a very small amount of foliage. Poor risks should be cut in order to salvage their value.

An overmature tree is one that has already attained large size for its species and shows evidence of decreasing vigor and quality. Decreasing vigor is shown by a slow and decreasing growth rate, scanty and pale foliage, a stag-headed crown (i.e., a crown with large dead branches at the top), and usually by bark that is much rougher and less uniform in thickness and color than is found on younger, fast-growing trees of the same species. Decreasing quality is not so readily observable, but implies that decay and other defects are developing faster than the tree is growing. Overmature trees should be removed in improvement cuttings because of their deterioration and progressive loss in value; they are trees that should have been harvested earlier when they were mature.

Most Delta hardwoods of the best and intermediate species do not become overmature until they are about 30 inches in diameter at breast height, but there is a considerable difference between species and also between individuals of the same species in this respect. Hackberry and persimmon are usually overmature after reaching 20 to 24 inches in diameter, whereas the red and

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[1] The 60 percent must be made up of sections at least 4 feet long that may occur on any or all 4 sides or faces of the log (conceived as squared), or of 3-foot sections aggregating at least 2/3 of the log length which are entirely clear full length for at least 7/8 of their circumference.

Kind of defect	External indications or occurrence	Importance
Surface knots	Limbs or stubs.	Prevent logs from being classed as high-grade when so placed that less than 60 percent is surface-clear.
Blind or hidden knots	Whorls or "puddles" that resemble the mark made by throwing a stone out of sight into soft mud.	Affect present clearness about same as surface knots. Quality will improve rapidly, however, with a good growth rate.
Visible decay	Usually associated with fire scars or limb stubs.	Likely to be overrated in fire-scarred gum, ash, and persimmon. Usually difficult to estimate, but most serious in old or slow-growing trees, and where a large proportion of the butt seems to be affected.
Hidden decay	Swollen trunk, old scars, discolored bark. Sometimes no external indication.	
Grub holes	Small exit holes (about 1/4" diameter) and small vertical scars. Most common in oaks, and usually in old slow-growing or injured trees.	If numerous, prevent logs from being classed as high-grade.
Bird peck	Sapsucker peck marks, usually circling the trunk.	Prevents logs from being classed as high-grade unless the marks are fresh and the log is large.
Bark pockets (small patches of bark embedded in the wood)	Rough or pitted bark, usually on old or slow-growing trees. Most common on oaks, hickories, and pecans. Difficult to determine.	If abundant, prevent logs from being classed as high-grade.
Ring shake (cracks between the annual rings)	No infallible guides, but most common in bitter pecan and in leaning or crooked trees.	Bad effect on lumber greatly increased if the tree has sweep. Prevents most bitter pecan from yielding high-grade logs.
Worm holes	Usually associated with open, infected injuries, usually fire scars. No certain indication.	If numerous, prevent logs from being classed as high-grade.
Mineral stain (blue or green discoloration of the wood)	Most common in unthrifty fire-scarred trees on the lowest and wettest sites. No certain indication.	Prevents logs from being classed as high-grade.

water oaks, redgum, cypress, and cottonwood usually reach 30 to 40 inches in diameter before they become decadent. Cypress is especially apt to go far beyond this limit. The approximate limits for other common species are: Mulberry, 12 inches; willow and red maple, 24 to 30 inches; and overcup oak, green ash, bitter pecan, rock elm, white elm, sycamore, and honeylocust, 26 to 36 inches. All species generally become overmature at smaller sizes on the poorer sites, and this is especially true of bottomland red oak.

(5) Position and space occupied. This consideration is important mainly in stands where most of the trees are relatively desirable. It is of comparatively little importance where most of the trees are intrinsically poor and undesirable. Only three classes of trees need be considered here: (a) Trees with poor growing space, (b) trees that interfere with better trees, and (c) wolf trees.

Trees with poor growing space are those that are overtopped by others or that are seriously crowded on at least 2 sides by trees of similar or larger size. This is not a reason in itself for cutting, but it may be a supplementary reason.

Trees that interfere with better trees are those which are so close as to prevent the best development of the better individuals. These interfering trees should be removed for obvious reasons.

Wolf trees are those with unusually large crowns. They occupy excessive space, especially when their quality is considered, and interfere with the development of better trees or of desirable seedlings that could get a start if the space were available. Wolf trees are usually of low quality because of limbs and knots of excessive number and large size, and because their trunks are clear for only a very short length above the ground. Wolf trees have no place in a well-managed forest.

Cutting Rules

It is impossible to make a general statement as to how far to go in removing poor or undesirable trees. Usually this is determined by the area to be covered in a given period and by the extent to which forest products can be used or sold. The principle that the poorest trees should always be cut first, however, is applicable in all cases. Specific cutting rules are accordingly presented below in four groups or sets. The first set of rules provides for the cutting of only the very poorest trees—those that should be cut first. If a heavier cutting seems desirable, the second set of rules should be used also. For a still heavier cutting, the third set of rules should be added. These three sets of rules have been combined in tabular form on page 10, since in fairly well-stocked stands this results in a suitable first improvement cutting. Going beyond this point probably is inadvisable except under special circumstances such as the immediate need for a large volume of wood per unit of area, or where the stand is exceptionally well stocked or overstocked. To provide for such a cutting, however, a fourth set of cutting rules is given.

The trees described below should be cut into products of the greatest possible use or value. Trees which contain so little usable material that they are not worth cutting, especially large culls that will seriously damage valuable neighboring trees if felled, should be killed by girdling. Trees that cannot be used at present, but contain appreciable potentially usable material, should not be cut until a use or market develops.

Cut first:

1. Poor risks (merchantable or useful trees unlikely to remain alive until the next cutting).

2. Trees seriously decayed or grubby, hence likely to decrease in value.

3. Overmature trees, which have passed their optimum development and should be harvested before further deterioration occurs.

4. Sawlog-size trees of the poorest species that do not contain at least one high-grade log, and of intermediate species that do not contain at least one usable log.

Cut second:

1. Trees of the poorest or intermediate species, regardless of size, that do not or will never contain at least one high-grade log and are either (a) wolf trees (occupying excessive space), or (b) trees that will have poor growing space even after the improvement cutting.

2. Trees of the poorest or intermediate species that interfere seriously with the growth of better trees (a) of the best species at least 4 inches in d.b.h.,[2] or (b) of intermediate species at least 6 inches in d.b.h.

Cut third:

1. Remaining sawlog-size trees of the poorest species regardless of position or quality.

2. Under-sawlog-size trees of the poorest or intermediate species that interfere seriously with the growth of better trees (a) of the best species at least 1 inch in d.b.h. or (b) of intermediate species at least 4 inches in d.b.h.

3. Sawlog-size trees of intermediate species that do not contain at least one high-grade log, or that are very large wolf trees not containing more than one high-grade log.

2/ D.b.h.—diameter at breast height, i.e., at 4½ feet above the ground.

4. Under-sawlog-size trees of the best species that (a) will never contain at least one high-grade log and will have poor growing space even after the improvement cutting, or (b) interfere seriously with better trees of intermediate or best species at least 4 inches in d.b.h.

5. Wolf trees of the best species that do not or will never contain at least one high-grade log, or more than one high-grade log if more than 20 inches in d.b.h., unless needed for seed.

6. Sawlog-size trees of the best species that do not contain at least one usable log, unless needed for seed.

Cut fourth:

1. Remaining under-sawlog-size trees of the poorest species.

2. Remaining under-sawlog-size trees of intermediate species that will never contain at least one high-grade log.

3. Remaining trees of the best species that do not or will not contain at least one merchantable or usable log, unless needed for seed.

Utilization of Trees Removed

Improvement cuttings ordinarily yield products mostly of low commercial value. Nevertheless, if the cutting is regulated with careful consideration of current needs and markets, and the better portion of the stand is left for further growth and increase in value, it should be profitable to improve all but the most inaccessible forest properties in the Delta. Although materials removed will be valuable mainly for domestic uses such as fuel wood and posts, most tracts will yield some material for which there is a good cash market. The products that may be obtained from improvement cuttings are discussed below, in order of increasing utility or value.

1. Fuel wood. Most fuel wood will be used on the plantation or in the immediate neighborhood, although towns not more than a short truck haul distant may offer good markets. The total amount of fuel wood used annually in the Delta is equivalent to several million board feet of logs, and a substantial part actually is cut from sawlog or potential sawlog trees. If fuel wood were obtained only through improvement cutting, a long step would be taken toward returning Delta woodlands to a productive and profitable condition. Fuel wood should be cut only from trees for which no higher use is available, such as inferior small trees, topwood, and cull trees that are too crooked or rough to work into higher-class products.

RULES FOR IMPROVEMENT CUTTING

<table>
<tr><td rowspan="2">Diameter at breast height in inches</td><th>Poorest species</th><th>Intermediate species</th><th>Best species</th></tr>
<tr><td>Boxelder
Waterlocust
Hawthorn
Planertree
Ironwood
Swamp privet</td><td>Overcup oak
White elm
Rock elm
Winged elm
Hackberry
Willow
Red maple
Sweet pecan
Bitter pecan
Hickories
Honeylocust
Sycamore
Blackgum
Swamp cottonwood</td><td>Bottomland red oak
Willow oak
Water oak
Cherrybark oak
Cow oak
Cottonwood
White ash
Green ash
Redgum
Persimmon
Mulberry
Cypress</td></tr>
<tr><td rowspan="2">5 - 13 (under sawlog size)</td><td colspan="3">Cut only:
(1) Poor risks (from viewpoint of survival).
(2) Trees seriously decayed or grubby.
(3) Trees that will never produce at least 1 high-grade log and that have poor growing space.
(4) Wolf trees that will never produce at least 1 high-grade log.</td></tr>
<tr><td colspan="2">(5) Trees that interfere seriously with better trees of the best species at least 1 inch d.b.h., or of intermediate species at least 4 inches d.b.h.</td><td>(5) Trees that interfere seriously with better trees of intermediate or best species at least 4 inches d.b.h.</td></tr>
<tr><td rowspan="2">14 and more (sawlog size)</td><td rowspan="2">Cut all trees.</td><td colspan="2">Cut only:
(1) Poor risks (from viewpoint of survival).
(2) Trees seriously decayed or grubby.
(3) Overmature trees.
(4) Wolf trees that don't contain at least 1 high-grade log, or wolf trees more than 20 inches d.b.h. that don't contain more than 1 high-grade log.</td></tr>
<tr><td>(5) Trees that don't contain at least 1 high-grade log.
(6) Trees that interfere seriously with better trees of the best species at least 4 inches d.b.h., or of intermediate species at least 6 inches d.b.h.</td><td>(5) Trees that don't contain at least 1 usable log.</td></tr>
</table>

A high-grade log is one that is at least 10 inches in diameter inside the bark at the small end, at least 12 feet long, straight enough to be handled as one piece, and with at least 60% of its surface entirely clear of defects.

Application, to insure flexibility and adaptation to widely different conditions:

More decay and grubbiness, and poorer form, are tolerated in the best species than in the other two groups.

Where the stand is light, or the trees very poor and the cut relatively heavy, poorer trees are tolerated than where the stand is heavy or the cut relatively light. Also, in light stands or in heavily cut stands, some trees of the best species may be left for seed production even though the rules call for cutting them.

2. Posts, pulpwood, and chemical wood. The straighter, cleaner portions of the stems of small trees down to 5 inches in diameter at breast height together with such 7-foot lengths of straight, clean material as occur in cull trees and tops often may prove of more value as posts than as fuel wood. Nothing should be used for posts that is suitable for a more valuable use. A small tree good enough to make a post often will make a high-grade sawlog when it is larger, and such trees should not be removed in an improvement cutting. Of the common Delta species, only heart cypress, heart overcup oak, and mulberry are worth using for untreated posts, since the others are subject to rapid decay. Much time and material is wasted in the Delta every year through the use for posts of species which decay and fail within 3 years. Most of these species, however, can be creosoted by the open-tank, hot-and-cold-bath process to provide posts of high durability.

Pulpwood is at present salable from only one Delta species, cottonwood, but it is probable that a demand for pulpwood from nearly all of the softer hardwoods will develop. Pulpwood should be cut from the same class of material that provides fuel wood, excluding material that will not yield a 4- or 5-foot length straight and clean enough to peel readily, and at least 4 inches in diameter. Wherever there is a market, pulpwood usually is the most profitable product for all sizes and qualities of material up to common sawlog or stave timber. Post utilization cannot compete with pulpwood except where preservative treatment is unnecessary.

At present chemical wood in the Delta can be sold to only one plant, which uses reasonably sound, straight wood of only the heavier species such as oak, pecan, locust, and rock elm. Size requirements are about the same as for pulpwood, but the bolts do not have to be peeled.

3. Stave, small-dimension, and specialty stock. The required quality is approximately the same for all of these uses, the principal differences being in species and value. Only clear, high-grade material is usable, but small sizes can be used down to 8 to 12 inches, and short lengths are generally acceptable and often preferred. The most valuable species is persimmon, which cannot be used in any other way except for treated posts and fuel wood. Ash is the next most valuable species, but except in small sizes and short lengths bottomland ash is equally valuable for lumber. At the other extreme, nearly all of the softer woods are readily salable as slack stave bolts at a low stumpage value. This value, however, is about as high as ordinary saw-timber value for most of these species except in the case of large choice logs, which will bring substantially more as saw timber. In fact the only ready market at all for some species is for slack stave manufacture. Hackberry is probably the best example of this.

Oak down to 12 inches is used to some extent for low-grade tight cooperage and also for direct cutting into blanks for implement and furniture stock, but stumpage values usually are low. Pecan is, less often, cut directly into blanks for implement stock and athletic goods at rather low values, and the use of small material is severely limited. It is desirable, therefore, to leave straight, clear, small trees of oak and pecan to grow into commercial saw timber whenever feasible, as in most cases the market would not absorb them and they would have to be used locally as low-grade sawlogs or posts.

4. Saw timber. Two distinct classes of saw timber must be recognized in any realistic consideration of hardwood utilization and values. In the first class are large, high-grade logs, reasonably clear of all types of defects and 16 to 20 inches and larger, plus especially clear logs down to about 14 and occasionally even 12 inches which come principally from the butts of the smaller trees. This is the class of timber cut by the hardwood lumber and veneer industries, which produce almost entirely for factory use. A fairly adequate market for such timber still remains in the Delta. Staple species, such as gum, oak, and ash are readily salable at good prices, while other species, such as elm, sycamore, and willow sell less readily and at lower prices for higher specifications. Pecan, rock elm, and locust are only occasionally salable, and then only to relatively few mills and at low prices for very high specifications.

The second class comprises the remaining sound, common sawlogs with no established commercial market. There is no outlet at any price for all or even a large proportion of this class of timber. Small fractions of the best of these sawlogs can be disposed of at low prices with (but never separate from) high-grade logs sold to lumber mills. Limited amounts may be sold in the form of ties, timbers, and planking, or cut up by small farm mills and used locally for the commonest types of construction. A large part of this class of timber, especially the thrifty small and medium-sized trees, should be retained as growing stock and should not be forced onto the market until it has become larger and of a quality more readily salable at a better price. Better manufacturing and marketing facilities for such timber undoubtedly will develop in the Delta, much as they have already developed in other hardwood regions.

Benefits of Improvement Cutting

The benefits obtained from improvement cuttings are especially substantial from the viewpoint of future rate of return upon the present investment. A rather large immediate net return often can be obtained by harvesting a variety of products in a single systematic improvement cutting, where little or nothing could be realized by haphazard cutting for a single product or by the usual random, destructive felling for plantation needs. The usual immediate result of improvement cutting, however, is a small net return over the costs of operation. In many circumstances, mere recovery of the greater part of the cost will justify the enterprise.

Any immediate net cash loss in an improvement cutting, or any net disadvantage in immediate income as compared to the possible returns of an unregulated cutting, should be regarded as an investment in the rehabilitation of the property and the building up of its productive capacity. Such a policy is comparable to the sound business practice of investing capital in the development of run-down and mismanaged but potentially profitable farms and plantations, looking toward the time when the property will again pay good returns on the investment. Aside from immediate income, the following advantages accrue from effective improvement cutting:

1. Use of high-quality trees for low-quality purposes is stopped and the trees either cut for their best use or left to grow and develop their full value. For example, it is common practice to fell thrifty young ash and red oak indiscriminately for fuel wood and high-grade oak for ties and farm lumber. This kind of cutting is the very opposite of improvement cutting.

2. A large volume of timber is cut and used that would ordinarily die of natural causes before it would be reached under the usual haphazard system of cutting and marketing. This has the additional advantage of saving an equivalent amount of promising growing stock which might be cut instead.

3. Only the more thrifty, promising trees are left as an investment, and their growth rate is increased by the removal of the competition of the poorer trees. Considering the great increase in volume over a period of years, together with the increase in value per unit volume, a very high rate of compound interest is earned on the relatively small capital value of the residual timber. This is especially true of the smaller trees left in an improvement cutting.

4. Removal of large trees of little value greatly increases the area in actual productive use by furnishing room and opportunity for new growth to seed in.

5. The ultimate effect in average cut-over and second-growth forests in the Delta will be to increase the present productivity about four times in volume (to about 400 board feet per acre per year, plus a substantial amount of cordwood and posts) and at least six times in value. Although returns will be low or even lacking for a number of years in all but the best second-growth stands, the eventual result will be a property that can be managed to yield a good sustained income.

SCIENTIFIC NAMES OF SPECIES MENTIONED IN TEXT

The common names used in the text are in most cases those in common use in the Yazoo-Mississippi Delta. These, together with the common names accepted by the Forest Service and the scientific names, are given below:

Common name in the Delta	Common name accepted by the Forest Service	Scientific name
Ash, green or swamp	Green ash	Fraxinus pennsylvanica lanceolata (Borkh.) Sarg.
Ash, white or cane	White ash	Fraxinus americana L.
Boxelder	Boxelder	Acer negundo L.
Black gum	Black tupelo	Nyssa sylvatica Marsh.
Cottonwood	Southern cottonwood	Populus deltoides virginiana (Castigl.) Sudw.
Cottonwood, swamp	Swamp cottonwood	Populus heterophylla L.
Cypress	Baldcypress	Taxodium distichum L. (Rich.)
Elm, rock	Cedar elm	Ulmus crassifolia Nutt.
Elm, white or soft	American elm	Ulmus americana L.
Elm, winged or hard	Winged elm	Ulmus alata Mich.
Hackberry	Sugarberry	Celtis laevigata Willd.
Hawthorn	Hawthorn	Crataegus spp.
Honey locust or thorn tree	Honeylocust	Gleditsia triacanthos L.
Ironwood	American hornbeam	Carpinus caroliniana Walt.
Maple, red or soft	Red maple	Acer rubrum L.
Mulberry	Red mulberry	Morus rubra L.
Oak, bottomland red or pin		Quercus nuttallii Palmer
Oak, cherrybark or scaly-bark	Cherrybark oak	Quercus rubra leucophylla Ashe
Oak, cow	Swamp chestnut oak	Quercus prinus L.
Oak, overcup or swamp post	Overcup oak	Quercus lyrata Walt.
Oak, water or striped or spotted	Water oak	Quercus nigra L.
Oak, willow or pin	Willow oak	Quercus phellos L.
Pecan, bitter	Water hickory	Hicoria aquatica (Mich.) Britt.
Pecan, sweet	Pecan	Hicoria pecan (Marsh.) Britt.
Persimmon	Common persimmon	Diospyros virginiana L.
Planer tree or water elm	Planertree	Planera aquatica (Walt.) Gmel.
Privet, swamp	Common adelia	Forestiera acuminata (Mich.) Poir.
Red gum	Sweetgum	Liquidambar styraciflua L.
Sycamore	American sycamore	Platanus occidentalis L.
Water locust or thorn tree	Waterlocust	Gleditsia aquatica Marsh.
Willow	Black willow	Salix nigra Marsh.

OCCASIONAL PAPER NO. 94 OCTOBER 4, 1940

SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

EARLY SURVIVAL OF COTTONWOOD AND HYBRID POPLAR PLANTATIONS AT STONEVILLE, MISS.

By

Henry Bull, Silviculturist
and
J. A. Putnam, Associate Forester
Southern Forest Experiment Station

In cooperation with
DELTA EXPERIMENT STATION, Stoneville, Miss.

The major portion of this study was carried on in cooperation with the Mississippi Agricultural Experiment Station under the Cooperative Farm Forestry Act of 1937.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration official project 65-2-64-74.

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Experimental plantations of native cottonwood cuttings and seedlings, and of 10 varieties of hybrid poplar cuttings, were established between January 30 and April 26, 1940, at the Delta Experiment Station, Stoneville, Miss. The plantations were examined June 18 - 21, 1940, to determine the early survival, and this paper is a report on the findings. The study is a part of a cooperative forest research program of the Southern Forest Experiment Station and the Mississippi Agricultural Experiment Station.

Established on forest land that before planting supported only a scanty stand of mixed hardwoods (not including cottonwood) and cypress, mostly culls or of low grade, the plantations are for the purpose of investigating and comparing different methods of reforesting such land with fast-growing trees that will yield merchantable pulpwood, or later sawlogs, in the shortest possible time. There have been few previous studies of forest planting in the Delta; hence there was little background of experience for the present study. Valuable advice was obtained, however, from Mr. R. D. Stevens, of the Department of Horticulture and Forestry, University of Arkansas, who had recently made experimental cottonwood plantings in the Delta region of Arkansas.

Planting Sites

One experimental plantation (designated D-2) occupies a well-drained "flat" that supported bottomland red oak, overcup oak, water hickory (bitter pecan), American elm, and other bottomland species. The other plantation (designated D-5) is divided by a shallow slough into a "ridge" and a shallow swamp. The ridge site is definitely higher than the site of the D-2 plantation, and once supported such species as redgum[1/] and water oak. The swamp supported cypress, waterlocust, swamp privet,[2/] and other swamp species, and was partially under water throughout the planting period. The D-2 site is too wet in the spring for profitable agricultural use except in unusually dry years. The D-5 ridge site is fair to good farm land, but the area is small and relatively inaccessible. The D-5 swamp site is entirely unfit for farming, even though there is a large drainage canal within a quarter-mile.

[1/] The common name recently accepted by the Forest Service for *Liquidambar styraciflua* is sweetgum.

[2/] Similarly, *Forestiera acuminata* is common adelia.

To provide more uniform conditions for experimental purposes, and to facilitate the planting and later examinations, the largely low-grade and cull trees on the D-2 site were girdled, and the sparse stand of similar trees on the D-5 sites was clear cut. On D-2 the planting was done in narrow lanes cut through the dense brush, weeds, and vines with "Kaiser" blades. On D-5 the entire planting area was cleared with Kaiser blades after the trees were removed. The brush, weeds, and vines sprouted vigorously in the spring and were 2 to 5 feet high in mid-June.

Planting Stock and Methods

Ten varieties of hybrid poplar cuttings were obtained from the Northeastern Forest Experiment Station, a branch of the U. S. Forest Service located at New Haven, Connecticut. These varieties were selected from among hundreds bred by that station as especially desirable for reforestation in the Northeast. Their growth and value in the Delta are problematical.

Cuttings from native cottonwood (Populus deltoides virginiana) were taken with pruning shears from vigorous shoots in the upper portions of freshly felled trees in stands between the levee and the Mississippi River near Greenville, Miss. The trees were mostly 2 to 8 inches in diameter, although a few were as large as 12 inches in diameter. "Fresh" cuttings were planted within 2 to 4 days of their preparation, being heeled into the ground or stored in shallow water in the meantime. "Stored" cuttings were kept in cold storage at a temperature of about 35° F. between the time of preparation (March 4) and that of planting. Four different lengths of cutting, two depths of planting for each length of cutting, and three dates of planting were tested with fresh cuttings. A single length of cutting and depth of planting at three different planting dates were tested with stored cuttings.

On site D-2 hybrid poplar cuttings and fresh cottonwood cuttings were planted at a time (January 30 - February 2) when cottonwood buds were completely dormant. On site D-5 cottonwood cuttings and seedlings only were planted. These plantings included one while the cottonwood buds were still dormant (March 6 - 8 and 11), one at the time the buds were beginning to open (March 25 - 27), and two after the buds had opened in the woods (April 15 - 17 and April 26). All cuttings were set in holes made by cylindrical planting bars. Bars of various diameters from 1/4 to 7/8 inch were used, depending on the diameters of the cuttings. An effort was made to obtain a tight fit for each cutting, and contact between the base of each cutting and the bottom of the hole.

Cottonwood seedlings were obtained from nearby ditches and borrow pits for experiment D-2, and from stands between the levee and the Mississippi River for D-5. Seedlings 1½ to 7 feet high and mostly 2 years old were selected and pulled up without any digging. The seedlings were then planted, after just enough trimming of the roots to permit planting in holes made by the same planting bars used for the cuttings. The tops of some seedlings were left unpruned, whereas others were cut back to 2, 4, or 18 - 24 inches. Both fresh and stored seedlings were planted, the former at the same dates as the cuttings, but the latter only at the last date.

Early Survival

For each test the number planted, the number "alive" (i.e., with green leaves) on June 18 - 21, 1940, and the percentage alive, are recorded in tables 1 and 2. These results are reported now because of the widespread interest in the tests and because of the large differences already in evidence. No detailed statistical analysis will be made until the survival for the complete growing season has been recorded, but inspection of the tables shows a number of interesting and probably significant results already obtained. An important point to note here is that the results have undoubtedly been affected to some extent by the unusually cold, wet spring weather experienced at Stoneville. Conditions suitable for growth were estimated to have occurred about 3 weeks later than usual.

The hybrid poplar cuttings exhibit a wide range of survival, from 36 to 97 percent. Four of the ten varieties show more than 85 percent survival, three show between 50 and 85 percent, and three show less than 50 percent. No other comment on the hybrid poplar cuttings seems necessary at this time.

A tabulation of the more successful planting tests in which native cottonwood cuttings and seedlings were used is given in table 3. The most outstanding results obtained with cottonwood planting stock may be summarized as follows:

1. Seedlings vs. cuttings. In general, seedlings showed higher survival than cuttings. The best survival among the seedlings was about 85 percent, compared with about 60 percent for the best cuttings.

2. Cutting back of seedlings vs. no cutting back. Seedlings that were cut back immediately after planting showed higher survival than seedlings not cut back. The survival of fresh seedlings planted during dormancy and cut back to various lengths up to 24 inches was 80 to 88 percent, whereas the survival of fresh dormant seedlings not cut back was 46 to 68 percent. The survival of stored dormant seedlings planted about one month after cottonwood buds opened in the woods, and cut back to various lengths up to 24 inches, was 69 to 100 percent, whereas the survival of stored dormant seedlings not cut back was lower by 12 to 28 percent.

3. Terminal vs. nonterminal cuttings. The survival of fresh dormant cuttings was not appreciably or consistently affected by the presence or absence of terminal buds on the cuttings.

4. Early vs. late planting during the dormant period. Planting 3 weeks and 8 weeks before cottonwood buds opened in the woods resulted in approximately the same survival.

5. Planting during dormancy vs. planting after growth started. Fresh cuttings and seedlings showed higher survival when planted during the dormant period than when planted after growth had started. The average survival of all fresh cuttings planted during the dormant period was 31 percent better (range, 6 to 57 percent better) than the average survival of all fresh cuttings planted 2 to 3 weeks after cottonwood buds opened in the woods. Fresh seedlings averaged 62 percent better survival (range, 38 to 80 percent better) at the earlier date.

6. Early vs. late planting of stored cuttings after growth started. The survival of stored cuttings was equally good at 2 to 3 weeks and at 4 weeks after cottonwood buds opened in the woods.

7. Stored vs. fresh cuttings, planted after the dormant period. Stored dormant cuttings showed higher survival than fresh cuttings when planted after the dormant period. Stored dormant 20-inch cuttings planted 16 inches deep showed 6 to 18 percent better survival when planted at the time cottonwood buds opened in the woods, and 46 to 52 percent better survival when planted 2 to 3 weeks after the buds opened, than fresh cuttings of the same specifications.

8. Date of planting in relation to exposed length of stock. The later the date of planting (except for stored material), the greater was the disadvantage of having a large proportion of the length of the planting stock above the ground.

9. Site in relation to date of planting. The effect of site on the survival of seedlings depended on the date of planting. On the ridge, fresh seedlings planted early showed better survival than stored seedlings planted late. In the swamp, however, stored seedlings planted late showed better survival than fresh seedlings planted early. These differences probably are due to the adverse effect of the ridge becoming dryer, and the beneficial effect of the swamp becoming dryer, as the season advanced. Fresh cuttings showed no consistent differences in survival between the ridge and the swamp at the earlier plantings, but higher survival in the swamp at the later plantings.

10. Length and depth of planting of the best cuttings in relation to site. Twenty-inch cuttings generally showed higher survival than shorter or longer cuttings, and the effect of depth of planting depended on the site. In the swamp better survival usually was obtained with relatively shallow planting, whereas on the ridge, relatively deep planting generally was better.

Conclusions

Present indications are that seedlings make the best cottonwood planting stock, that they should be obtained and planted before the buds open in the spring (or obtained at that time and held in cold storage if the planting is to be done after growth has started), and that they should be cut back to 24 inches or less immediately following planting. If fresh seedlings are used, ridges may be planted at any time before cottonwood buds open in the woods, but swamps should be planted as late in the dormant period as possible. If stored seedlings are used, ridges should be planted soon after growth starts in the woods, and swamps should be planted later when the water table is much lower. A more complete analysis and report will be made following the survival examination in the fall of 1940, at the end of the first complete growing season.

Table 1.—Experiment D-2: Summary of survival on June 18 - 21, 1940 of plantings made January 30 - February 2, 1940

Site: flat

Species and class of stock	Length of cutting	Depth of planting	Total Planted	Total Alive
	- - Inches	- -	Number	Percent
Hybrid poplar cuttings				
(Nonterminal[1])				
Oxford Paper Co. No. 6 (P. nigra x P. laurifolia)	12	9	87	60
Oxford Paper Co. No. 14 (P. charkowiensis x P. balsamifera virginiana)	12	9	87	71
Oxford Paper Co. No. 21 (P. charkowiensis x P. caudina)	12	9	87	66
Oxford Paper Co. No. 29 (P. charkowiensis x P. trichocarpa)	12	9	88	91
Oxford Paper Co. No. 33 (P. angulata x P. berolinensis)	12	9	88	45
Oxford Paper Co. No. 39 (P. petrowskyana x P. caudina)	12	9	88	86
Oxford Paper Co. No. 42 (P. maximowiczii x P. trichocarpa)	12	9	88	89
Oxford Paper Co. No. 48 (P. maximowiczii x P. berolinensis)	12	9	87	36
Oxford Paper Co. No. 53 (P. maximowiczii x P. caudina)	12	9	88	49
Oxford Paper Co. No. 55 (P. tacamahacca clon candicans x P. berolinensis)	12	9	88	97
Fresh cottonwood cuttings				
Terminal cuttings[1]	12	9	44	57
Nonterminal cuttings	12	9	44	45
Terminal cuttings	16	12	43	51
Nonterminal cuttings	16	12	44	50
Terminal cuttings	20	15	43	47
Nonterminal cuttings	20	15	43	53
Fresh cottonwood seedlings				
Cut back to 2-inch stem			44	84
Not cut back			44	68

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[1] A terminal cutting is one made from the end of a shoot, including the last or terminal bud.

Table 2. -Experiment D-5: Summary of survival on June 18 -'21, 1940 of cottonwood plantings made March 6 - April 26, 1940

Class of stock	Length of cutting	Depth of planting	Site	Date of planting							
				March 6 - 8		March 25 - 27		April 15 - 17		April 26	
				planted	alive	planted	alive	planted	alive	planted	alive
	- - - Inches	- - -		No.	Percent	No.	Percent	No.	Percent		
Fresh cuttings	10	6	Ridge	100	17	99	18	100	3		
	10	6	Swamp	97	28	99	35	98	19		
	10	8	Ridge	100	35	100	44	100	0		
	10	8	Swamp	83	30	89	42	83	4		
	20	12	Ridge	99	54	100	36	100	6		
	20	12	Swamp	99	55	100	35	100	3		
	20	16	Ridge	100	64	100	53	100	7		
	20	16	Swamp	97	26	100	29	98	3		
	40	15	Ridge	100	33	100	17	100	1		
	40	15	Swamp	99	37	99	30	100	6		
	40	20	Ridge	100	53	100	27	100	1		
	40	20	Swamp	100	36	100	23	100	15		
	60	18	Ridge	50	24	50	10	50	2		
	60	18	Swamp	50	40	50	14	50	6		
	60	24	Ridge	50	32	50	16	49	4		
	60	24	Swamp	50	38	49	8	50	32		
										No.	Percent
Stored cuttings	20	16	Ridge			100	71	100	53	100	53
	20	16	Swamp			98	35	100	55	100	54
	Top cut back to			March 11							
Fresh seedlings	4	--	Ridge	25	88	12	92	12	8		
	4	--	Swamp	25	80	11	73	12	25		
	18 - 24	--	Ridge	25	80	13	69	13	15		
	18 - 24	--	Swamp	25	88	13	85	13	15		
	Not cut back	--	Ridge	50	64	25	88	25	4		
	Not cut back	--	Swamp	50	46	25	52	25	8		
Stored seedlings	4	--	Ridge							12	83
	4	--	Swamp							12	92
	18 - 24	--	Ridge							13	69
	18 - 24	--	Swamp							13	100
	Not cut back	--	Ridge							25	48
	Not cut back	--	Swamp							25	84

Table 3.—Cottonwood planting stock with at least 25% survival, both plantations

Site	Planting date							
	March 6 – 8		March 25 – 27		April 15 – 17		April 26	
	Kind of stock[1]	Survival	Kind of stock[1]	Survival	Kind of stock[1]	Survival	Kind of stock[1]	Survival
		Percent		Percent		Percent		Percent
Ridge (D-5)	Fresh sdlgs. 4"	88	Fresh sdlgs. 4"	92	Stored ctgs. 20-16"	53	Stored sdlgs. 4"	83
	Fresh sdlgs. 20"	80	Fresh sdlgs. Uncut	88			Stored sdlgs. 20"	69
	Fresh sdlgs. Uncut	64	Stored ctgs. 20-16"	71			Stored ctgs. 20-16"	53
	Fresh ctgs. 20-16"	64	Fresh sdlgs. 20"	69			Stored sdlgs. Uncut	48
	Fresh ctgs. 20-12"	54	Fresh ctgs. 20-16"	53				
	Fresh ctgs. 40-20"	53	Fresh ctgs. 10-8"	44				
	Fresh ctgs. 10-8"	35	Fresh ctgs. 20-12"	36				
	Fresh ctgs. 40-15"	33	Fresh ctgs. 40-20"	27				
	Fresh ctgs. 60-24"	32						
Swamp (D-5)	Fresh sdlgs. 20"	88	Fresh sdlgs. 20"	85	Stored ctgs. 20-16"	55	Stored sdlgs. 20"	100
	Fresh sdlgs. 4"	80	Fresh sdlgs. 4"	73	Fresh ctgs. 60-24"	32	Stored sdlgs. 4"	92
	Fresh ctgs. 20-12"	55	Fresh sdlgs. Uncut	52	Fresh sdlgs. 4"	25	Stored sdlgs. Uncut	84
	Fresh sdlgs. Uncut	46	Fresh ctgs. 10-8"	42			Stored ctgs. 20-16"	54
	Fresh ctgs. 60-18"	40	Stored ctgs. 20-16"	35				
	Fresh ctgs. 60-24"	38	Fresh ctgs. 10-6"	35				
	Fresh ctgs. 40-15"	37	Fresh ctgs. 20-12"	35				
	Fresh ctgs. 40-20"	36	Fresh ctgs. 40-15"	30				
	Fresh ctgs. 10-8"	30	Fresh ctgs. 20-6"	29				
	Fresh ctgs. 10-6"	28						
	Fresh ctgs. 20-16"	26						
	January 30 – February 2							
Flat (D-2)	Fresh sdlgs. 2"	84						
	Fresh sdlgs. Uncut	68						
	Fresh ctgs. 12-9"	51						
	Fresh ctgs. 16-12"	51						
	Fresh ctgs. 20-15"	50						

[1] The figures following "sdlgs" (seedlings) represent the height in inches to which they were cut back after planting. The figures following "ctgs" (cuttings) represent the length and the depth of planting, respectively, each in inches.

OCCASIONAL PAPER NO. 95 OCTOBER 9, 1940

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

THE LITTLE-LEAF DISEASE OF SHORTLEAF PINES

By

Paul V. Siggers and K. D. Doak, Associate Pathologists
Division of Forest Pathology, Bureau of Plant Industry
In cooperation with the Southern Forest Experiment Station,
Forest Service, U. S. Dept. of Agriculture

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Introduction

A widespread disease of shortleaf pine trees (P. echinata Mill.) in the Southeast has attracted the attention of foresters and owners of timberland in recent years. It was first reported in 1935 from Tallapoosa County, Ala., by Mr. D. J. Weddell[3], who also made the first report from Georgia in 1939. There is good evidence that this disease has been present for a number of years in northwestern Alabama.

At first the disease did not seem particularly significant. However, in the spring of 1939 the attention of pathologists of the Bureau of Plant Industry was called to a stand in the vicinity of Plantersville, Ala., where numerous mature 3-log shortleaf pine trees were found to be slowly dying from some obscure cause. Scouting has now shown the same trouble in varying stages at other places. Trees 4 inches in diameter at breast height and larger were found affected. As paucity of foliage and unusually short needles are constant symptoms of the disease, it has been named "little-leaf." Although loblolly pine (P. taeda L.) is also affected, this disease occurs principally on shortleaf pine.

In areas where the disease has been present long enough to kill a considerable number of trees, the proportion of the survivors showing disease symptoms is often very high. In an even-aged pine stand, a tally showed 32 living shortleaf pines and 15 dead standing trees on 1/2 acre. Of the former, 25 showed symptoms of the disease. About a quarter of a mile away, in a younger stand of shortleaf pine where the dominants were 20-30 years old, a tally showed 5 dead trees, 76 with disease symptoms, and 57 apparently healthy trees on 3/8 acre.

The progress of the little-leaf disease in a stand of timber is characteristically sporadic and unlike that caused by other killing agencies. While trees with the little-leaf disease usually are found in groups, affected trees drop out of the stand as individuals; and dead, dying, and apparently healthy trees may be intermingled in the same group (fig. 1-B,D). Furthermore, little-leaf symptoms do not appear until trees are about 20 or more years old.

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[1] Forest Pathology 40-38.

[2] For advice or assistance in this investigation, the writers wish to express their appreciation to Prof. L. M. Ware, Alabama Polytechnic Institute, and Mr. R. H. Page, Jr., Extension Forester, Auburn, Ala.; Mr. G. D. Evans, Forester, Alabama Power Co., Birmingham; Mr. C. J. Calloway, Hamilton, Ga.; and Mr. R. H. Erkel, Soil Conservation Service, Cullman, Ala.

[3] Dean, School of Forestry, University of Georgia, Athens, Ga.; formerly Assistant Professor of Forestry, Alabama Polytechnic Institute, Auburn, Ala.

FIGURE 1

LITTLE-LEAF DISEASE OF SHORTLEAF PINE

A. Dominant shortleaf pine, showing characteristic symptoms of the little-leaf disease.

B. Shortleaf pine stand with most of the trees showing symptoms of the disease.

C. Apparently healthy and diseased shortleaf pines growing side by side. Note development of suckers along the larger branches.

D. Longleaf pine surviving among dead and dying shortleaf pines, indicating that it is more resistant.

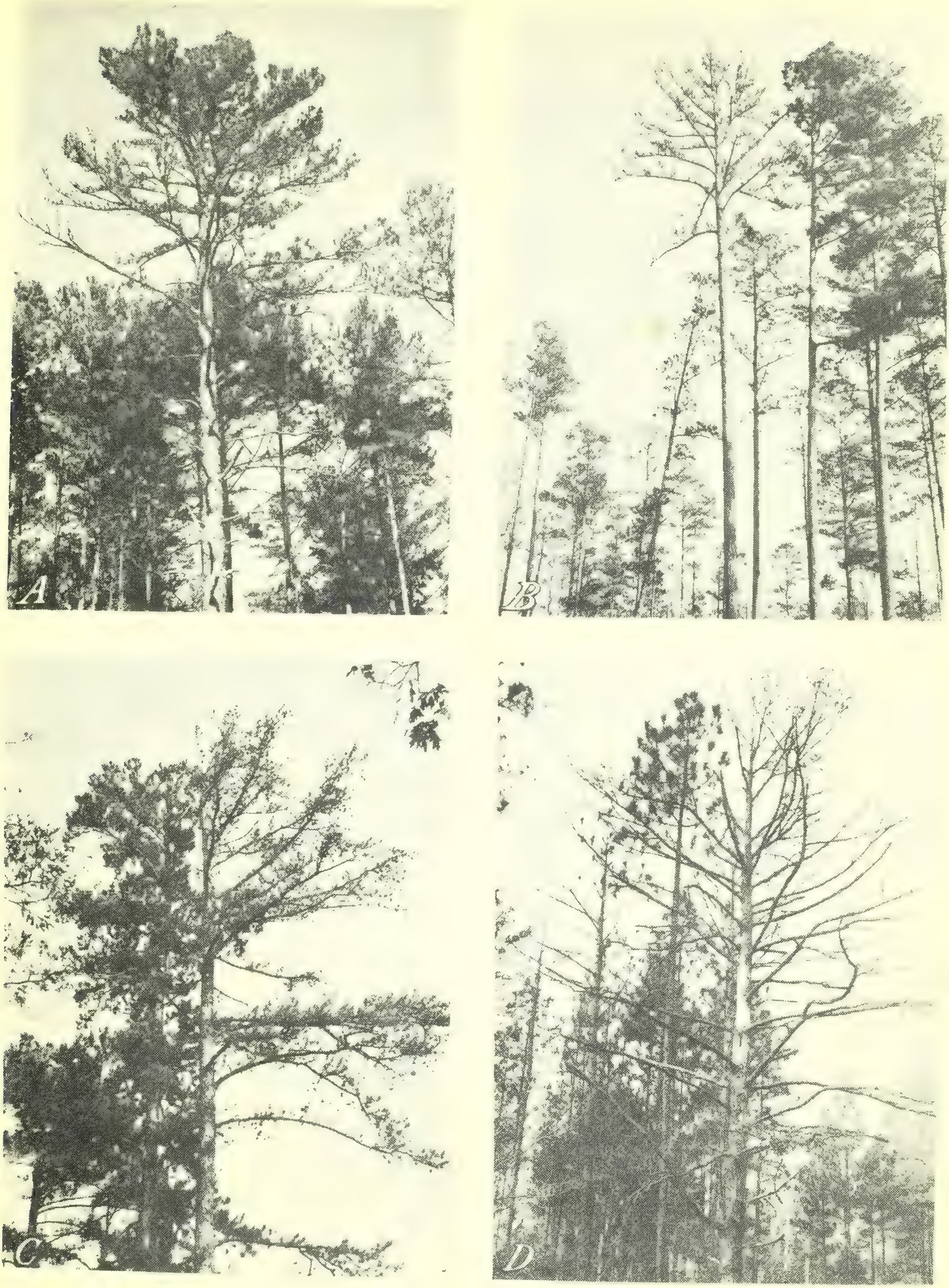

Fig. 1. Little-leaf disease of shortleaf pine. For explanatory legend,see opposite page.

This paper has been prepared in order to call attention to the disease and to summarize for foresters and timberland owners the information now available concerning it.

Relative Susceptibility

Shortleaf pine is much more susceptible to the little-leaf disease than other southern pines, as indicated by the greater prevalence of the disease on shortleaf admixed with other species of pine. In one stand, for instance, 50 of 108 shortleaf pines and 4 of 40 loblolly pines showed symptoms of the disease. Although definite little-leaf symptoms have not been found on longleaf pine (P. palustris Mill.), it must not be concluded that this species is immune to the disease. The survival of longleaf pine, however, in places where associated species have been killed by the disease (fig. 1-D), indicates that longleaf pine, if susceptible, is the least so of the three species studied.

Symptoms

As yet there has been no opportunity to trace the progress of the disease chronologically from its initial stages on individual trees. In the following description, which is based on observations on shortleaf pine in several localities where all stages of the disease occur, the various symptoms are given as they are believed to appear in sequence, but the time factor is still unknown.

The first symptom of the little-leaf disease is a uniform thinning of the foliage, caused by premature shedding of part of the needles of the second and third growing seasons. Usually this condition is followed by death of the branches (fig. 1-A), starting with those nearest the ground. Needle color turns from green to light greenish yellow, with the yellowing apparently intensified as the season advances. Needle length is reduced until the average length of needle on diseased trees is about half that of the foliage on healthy trees growing under similar environmental conditions. Dieback of branch terminals is common. Occasionally, suckers arising from adventitious buds give a feathered appearance to the larger branches (fig. 1-C). During the final stages of the disease, the scanty, chlorotic, and unusually short foliage is confined to wood of the current season's growth.

Disease symptoms vary somewhat, probably depending on the species of pine. The foliage of badly diseased loblolly pines, for example, is appreciably greener than that of diseased shortleaf pines growing on the same site.

The roots of pine trees attacked by the little-leaf disease have been found consistently defective. The finer roots on the laterals are often dead and break off readily in the soil while being excavated. Most of the larger roots are alive, but cross sections show shallow, cortical lesions extending into the living phloem almost to the cambium. Resin ducts in the wood of the larger roots are often stained reddish brown. Black, sooty masses composed of soil and oxidized resin, bound together by dark fungus strands, are sometimes found adhering to the bark of freshly extracted roots; the woody parts of the roots covered by these masses are so heavily infiltrated with resin as to appear water-soaked.

In a study of recent radial growth, based on approximately 50 increment cores from diseased and healthy trees in several localities, about two-thirds of the diseased trees showed a very sharp reduction in growth, starting 2 to 16 years ago. The remaining one-third showed a gradual reduction in radial growth that gave no indication when the disease had started. Radial growth of healthy trees, on the other hand, showed either a gradual reduction for many years or no reduction, depending on the relative age of the tree sampled, but 2 of 19 apparently healthy trees showed a sharp reduction in radial growth, starting 3 and 6 years ago. It is possible that some of the trees now thrifty have had the disease and have recovered.

Distribution

Surveys between August 1939 and the last of June 1940 showed the little-leaf disease to be distributed (see fig. 2) from the vicinity of Shelby, N. C., south and southwestward through the Piedmont in South Carolina, Georgia, and Alabama. West and northwest of the Piedmont, in Alabama, the disease is distributed in a zone about 75 miles wide, paralleling the Black Prairie on the north. Its western limit, as now known, is in eastern Itawamba County, in northeastern Mississippi. Since the map was prepared the disease has also been reported in south central Virginia.

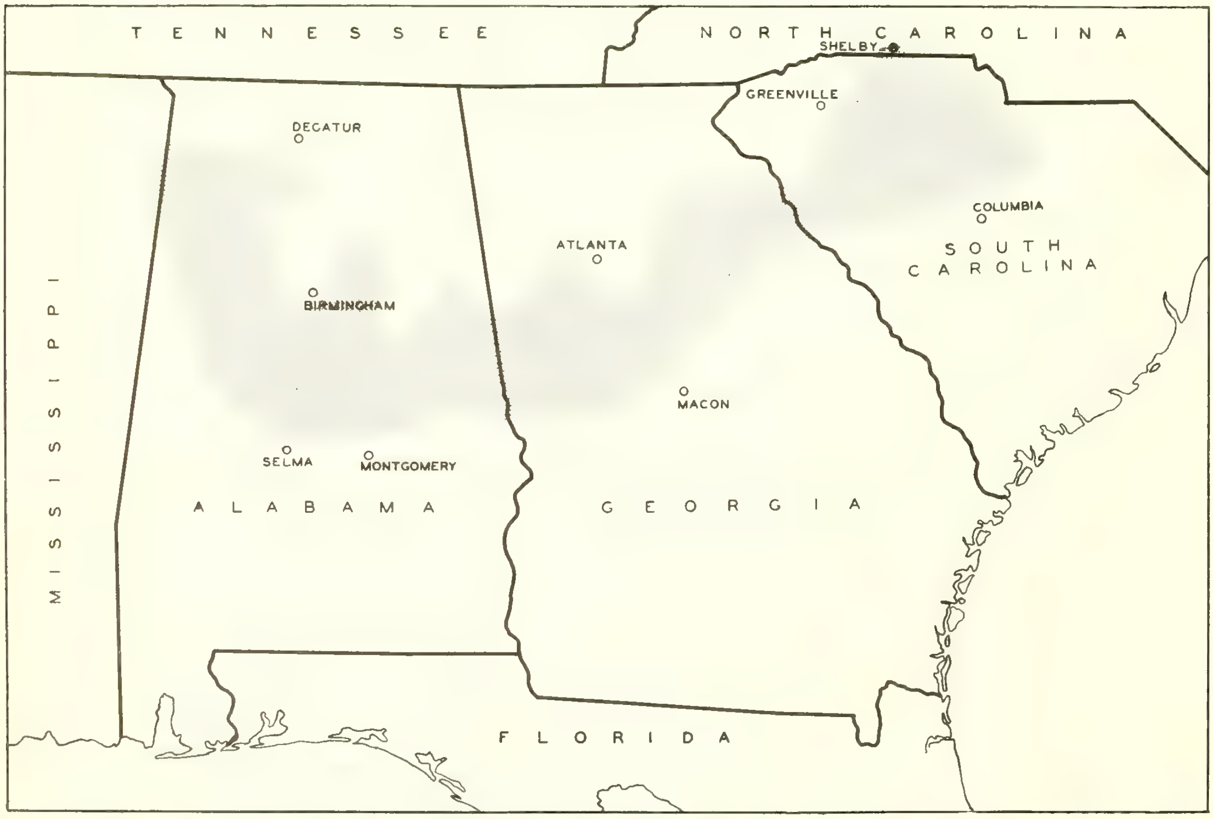

FIGURE 2.- DISTRIBUTION OF THE LITTLE-LEAF DISEASE OF PINES IN THE SOUTHEASTERN STATES AS DETERMINED BY ROADSIDE SURVEYS BETWEEN AUGUST 7, 1939 AND JUNE 18, 1940.

Theories as to Cause

The cause of the little-leaf disease has not yet been determined. A number of theories have been proposed, but there seem to be strong arguments against any one of them alone. The abrupt drop in radial growth, usually several years before death, characteristic of most little-leaf trees, and the contrasting good health of associated loblolly and longleaf pines argue against nutritional disturbance as a causative factor. These observations, together with the fact that precipitation has been about normal for the last 7 or 8 years over most of the little-leaf belt, suggest that this disease is not due simply to lack of water. Drought occurred in 1924-25 and in the early thirties, but the disease has increased appreciably during the last 4 or 5 years. The temperatures during recent years have been consistently slightly above normal. Just how this might bring about little-leaf seems obscure. The disease might be caused by a virus, but no virus disease of conifers is known, and this possibility also seems remote because symptoms do not appear until the trees are close to 20 years old. Root parasitism might account for little-leaf, but the presence of healthy seedlings and saplings in the immediate vicinity of diseased trees argues against the existence of a virulent soil-inhabiting organism. Without marshaling all of the arguments for and against the theories on the cause of little-leaf, it suffices to say that at present it appears that no single factor is responsible for the disease.

Summary

A gradual but widespread dying of pine trees due to unknown causes has been found in the Southeastern States. Deterioration of the feeding roots is involved. The main symptoms of the disease above ground are (1) premature loss of foliage, (2) death of branches, starting with those closest to the ground, and (3) persistence on the twigs of short, yellowish needles of the current growing season.

Little-leaf disease is distributed, in the main, in a crescent-shaped area, 50 to 75 miles in width, extending through the southern part of the commercial range of shortleaf pine in South Carolina, Georgia, and Alabama. Its northern extension, recently found in south central Virginia, is not shown on the map (fig. 2).

Observations in mixed stands of native pines indicate that shortleaf is the most susceptible species and that loblolly pine is much less affected. No longleaf pines have been seen with definite symptoms of the disease.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration, Official Project No. 65-2-64-74.

OCCASIONAL PAPER NO. 96 OCTOBER 14, 1940

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PULPWOOD AND LOG PRODUCTION COSTS AS AFFECTED BY TYPE OF ROAD

By

R. R. Reynolds, Forest Economist
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Use of motor trucks for the hauling of logs, pulpwood, and other forest products has increased tremendously in the past few years and many timber-using companies now obtain most or all of their requirements by truck transport. It is generally known that this method of transporting raw products from the stump to the mills is a cheap and effective one and will likely be used for a long time. Since this is true, some companies have realized that a system of good roads is quite necessary and have undertaken a large-scale program of road building.

The companies that are building roads, as well as those that are considering such a project, naturally are very much interested in what effect such an expenditure of funds will have on the per-unit production cost for pulpwood, sawlogs, etc. If, in a given instance, road building lowers the cost of production to the extent that the saving on hauling costs is greater than the cost of the road building, it would be poor economy not to do the building. But if the opposite were true, it would be desirable to depend as at present upon nongraded woods and other low-quality roads and the usual long skidding distance during the wet season.

This question of roads is also directly connected with the question of contract rates allowed for hauling forest products. It is customary for the lumber and pulp companies to pay a given unit price for hauling over a given distance or for all hauling within a certain radius of the mill or railroad. This price is usually the same regardless of the type or types of road that must be traversed. Thus, the contractor who has a job where the hauling is all, or practically all, over a good gravel or hard-surfaced road may make a satisfactory to good return on his investment, whereas the second contractor who hauls the same distance but over ungraded woods or rough dirt roads may lose money on his operation.

In order to determine what effect type of road has upon hauling cost, upon total production costs, and upon equitable contract rates, the Southern Forest Experiment Station recently undertook a study of production costs for logs and pulpwood, under dry weather conditions, in the pine-hardwood region of northern Louisiana, southern Arkansas, and eastern Texas. This study, here presented, is supplementary to other studies recently made, but it should be pointed out that because of rapid changes in trucking technique the following information is not the final word on the subject. Considerable variation in logging equipment, type of ground, length of logs, etc., occurs from one locality to another, and the cost figures presented must be adjusted to specific conditions.

Method of Study

As is true in all lines of work, forest products crews are not all equally efficient. Some are above average in the amount of pulpwood or logs they can cut or load or haul per day, some are just average, and because of laziness, physical inferiority, age, or lack of good equipment, some are far below average. Since an efficient company or an efficient contractor is not interested in production costs based on the productive capacity of an inefficient crew, an effort was made to select for this study only those crews and individuals who were average or better than average.

A total of six different sawlog operations and six different pulpwood operations were studied, all of which were run by independent contractors who were producing logs or pulpwood for a pulpmill or sawmill at a definite rate per unit. One each of the pulp and log contractors had only one truck operating. The others had from two to five each. Where possible, two trucks were studied on each job.

Since selective logging is so widely used in this region, all results are based on the removal of products from selectively-cut or selectively-thinned stands. Both pine and hardwood trees were cut into logs, and from 30 to 60 percent of the volume of the stands was removed in each instance. In general, no logs were cut that measured less than 10 inches diameter inside bark at the small end. Pulpwood came from tops of sawlog trees as well as from entire trees. Only pine timber was cut as pulpwood, and the volume removed per acre also averaged from 30 to 60 percent of the stand. For both logs and pulpwood, most of the trees cut were the semi-mature, mature, suppressed, or the defective.

Without exception the pulpwood trucks studied were of the low-priced kind and of $1\frac{1}{2}$-ton capacity, having dual wheels on the rear and capable of hauling two units or two standard cords of wood.

The trucks used on the log-hauling jobs were of the same makes and same rated horsepower as the pulpwood trucks. Several of them had special transmissions giving considerably more power in extreme low gear. All log contractors used steel trailers with two dual wheels and 6- to 7-foot bunks.

Because quite complete data were already available on felling and bucking for both pulpwood and logs and also for the skidding and loading of logs, very little detailed information on these operations was collected at the time of this study. Nevertheless, the total production and total hours worked per day in sawing, skidding, and loading were recorded for all crews employed by each of the contractors selected for study.

In order to check previously acquired data on truck loading and hauling costs and to determine the average time and cost per unit per mile for hauling over three common types of road, the following information was collected on each truck studied:

1. Number of men and teams serving one truck.
2. Work time, including necessary delays, per day for teamster, truck driver, and helpers.
3. Loading time per load.
4. Actual volume of each load, in board feet Doyle-Scribner rule for logs and in units for pulpwood.
5. Loaded travel time for ungraded and unprepared woods roads, for graded dirt roads, and for gravel or hard-surfaced roads traversed on each trip to landing or mill. Also, distances in miles and tenths of a mile for each type traversed on each trip.
6. Unloading time at mill or landing.
7. Return time and distance for each type of road traversed.
8. Number of effective round trips per day.
9. Amount of necessary or unnecessary delay and cause.
10. Approximate cut per acre.
11. Apparent efficiency of crew.

Cost of Log and Pulpwood Cutting

The average production per 8-hour day for all log felling and bucking crews studied amounted to just a fraction over 6,000 feet, Doyle-Scribner rule. Hence, approximately 1.33 crew-hours were required per M feet. The total labor cost plus the amount necessary for supervision, oil, wedges, saw filing, and depreciation amounted to $0.706 per crew-hour (see table 1). Thus, without allowing for profit and risk the cost per M feet (Doyle-Scribner rule) amounted to $0.941.

Table 1.—Estimated hourly cost of a felling and bucking crew of two men

	Dollars	
A. Current operating costs		
1. Direct labor cost		
Labor—2 men	.600	
Social Security—employer 4% (of $0.600)	.024	
Total direct labor cost		.624
2. Other direct cost		
Supplies—oil, wedges, etc.	.026	
Maintenance	.004	
Supervision	.043	
Total other direct cost		.073
B. Ownership cost		
1. Depreciation of saw, axes	.008	
2. Interest, taxes, insurance	.001	
Total ownership cost		.009
Grand total		.706

The average production of pulpwood per crew per 8-hour day was 4.005 standard cords, or approximately 2 crew-hours per standard cord. At $0.706 per crew-hour, the net cost per standard cord amounts to $1.412.

Assuming that the higher cost of 4½- and 5-foot wood is in direct proportion to the larger cubic volume of the unit over the standard cord (the actual difference is somewhat less), the cost of the 4½-foot wood is $1.588 and of the 5-foot wood $1.765 per unit. This is net cost; no allowance has been made for profit and risk. If 10 percent were added to cover this item, the cutting cost would be $1.553 per standard cord, or $1.747 per 144-cubic-foot unit, or $1.942 per 160-cubic-foot unit. An allowance of 15 or 20 percent for profit and risk would increase this cost in proportion.

Cost of Log Skidding and Loading

Practically all log skidding and loading on trucks in the region covered by the study is done with single teams of horses or mules. Except on very long or very short hauls one team and driver is usually allotted each truck, and unless there is a large amount of underbrush the teamster is expected to do his own swamping and preparing of "sets" for loading. In the present instance a swamper was used part time on several of the jobs; therefore it is assumed that one man will be used half time with each loading crew.

The estimated hourly cost (table 2) is $0.617 for the teamster and driver, and the cost of one swamper half time will be $0.156 per hour, a total of $0.773 per hour. With an average output of 700 feet Doyle-Scribner rule per hour the cost of the log skidding and loading (exclusive of the cost of truck and driver) is $1.104 per M feet, Doyle-Scribner rule.

Table 2.—Estimated hourly cost per crew of one team and driver in skidding and loading logs

	Dollars	
A. Current operating costs		
1. Direct labor cost		
Teamster	.300	
Social Security—employer 4% (of $0.300)	.012	
Total direct labor cost		.312
2. Other direct cost		
Feed	.187	
Harness and equipment upkeep	.025	
Supervision	.043	
Total other direct cost		.255
B. Ownership cost		
1. Depreciation of team	.041	
2. Interest on investment, taxes, etc.	.009	
Total ownership cost		.050
Grand total		.617

Time Required for Loading, Unloading, and Delay

In order to determine the truck-hauling fixed costs (which do not vary with length of haul) per cord and per unit of pulpwood for the pulpwood production portion of the study and the fixed costs per M feet (Doyle-Scribner rule) for log production, the total time required to complete the loading in the woods and to unload at the mill or landing, together with the delay time chargeable to each of these operations, was obtained for each load studied. This fixed time for pulpwood loads averaging 1.98 units of 4 x 4½ x 8 feet, and for loads of logs averaging 1,450 feet (Doyle-Scribner rule) per load is given in table 3. The same data would apply equally to loads of pulpwood of 1.98 cords of 4-foot bolts, or of 1.98 units of 5-foot bolts.

Table 3.—Time required per load

Product	Load	Unload	Delay	Total	Basis
	Minutes				No. loads
Pulpwood	44.87	26.61	4.14	75.62	84
Logs	41.30	13.70	9.20	64.20	184

Hauling Time for Various Types of Road

In the relatively flat to gently rolling area in which the present study was made, woods roads are for the most part not roads at all, but merely trails cleared of brush and small trees, over which the trucks can travel from the loading place at or near the point of cutting to the dirt or higher-quality roads. As may be expected, these trails are not straight and are usually quite rough. In dry weather trucks have little difficulty in traveling over such "roads" with a full load, but it is usually necessary to run in first or second gear. In an area where it is necessary, before reaching a road of higher quality, to travel relatively long distances over a woods road, the time required per load may be one-half hour or more. As a result of this, the number of loads possible per day may be two or more per day less than would be possible with a graded, straight, and fairly level road near the place where the cutting is being done. Consequently, the cost for hauling per unit of pulpwood, or per M board feet of logs, over a long distance of woods road may be considerably greater than for hauling the same products over the same distance of graded or high-class road. Therefore, if sufficient volume is to be moved over this woods road, it may pay to build a higher-class road into the area before cutting begins.

In order to present data which a lumber or pulp company or logging contractor could use to determine what roads should be built and where, it was necessary to determine the different costs of hauling; accordingly, records were made of the time required to haul logs and pulpwood over the various types of road. The data obtained are given in table 4.

Table 4.—Time required per load per mile round trip

Product	Type of road		
	Woods	Graded dirt	Gravel or hard surface
	Minutes		
Pulpwood	22.7	7.9	4.7
Logs	21.1	8.6	4.5

Truck Operating Costs

Since the cost of hauling a given quantity of pulpwood or logs varies not only with the volume per load but also with the length of the haul, the truck operating costs have been divided into "fixed expenses" per hour of operation and running expenses per mile of hauling distance. The running expenses have been computed separately for woods roads and for graded dirt and better-quality roads. This distinction is made because the gasoline mileage and tire life for woods roads is considerably less than for graded dirt or gravel roads.

The estimated operating-cost figures for trucks used in pulpwood hauling are given in table 5, and for trucks used in log hauling in table 6. It will be noted that the cost of the driver and the average of 1.63 helpers used on the pulpwood trucks is included in the fixed costs per hour totaling $1.063. Also the cost of the driver for the log trucks is included in the total fixed costs of $0.585 per hour for the log hauling. Because trailers are used in the log hauling but not in the pulpwood hauling, and also because pulpwood trucks get better gasoline mileage, the running cost per mile for log trucks on low-quality roads is $0.121 as compared to $0.087 for pulpwood trucks. For high-quality roads the figures are $0.067 and $0.051. Trucks usually operate 10 hours per day, the owner or employee other than the regular driver taking the last load to the landing or mill.

Summary of Pulpwood Production Costs

In table 7 pulpwood production costs are summarized for standard cords and for units of 144 cubic feet (4 x 4½ x 8 feet) and of 160 cubic feet (4 x 5 x 8 feet). The cost of hauling is necessarily figured on a basis of mileage from the point of loading to the point of unloading. The expense per mile presented in the table includes that of the return trip.

Following is an explanation of the method used to obtain the figures in table 7. The computation of felling and bucking cost has been discussed (page 3). The loading, unloading, and delay (table 3) take 75.62 minutes or 1.260 hours per load of 1.98 standard cords (or the same number of units) at $1.063 per hour, which is equivalent to $0.677 per cord or unit. The hauling time (table 4) per load over woods roads, including the return trip, is 22.7 minutes per mile. Converted to hours this amounts to 0.378 hours, and at $1.063 per hour (table 5) the fixed hauling cost of each load per mile is $0.402. To this must be added the running expenses per mile of $0.087, or $0.174 per mile round trip, making a total of $0.576 per load of 1.98 cords

Table 5.—Estimated costs per truck used for pulpwood hauling

$1\frac{1}{2}$-ton 85-hp. truck

	Dollars
Investment	
Truck complete with cab and dual wheels	950.00
Minus tires[1/]—6 at $50	-300.00
Net investment	650.00
Minus trade-in value—truck	-200.00
Amount to be depreciated	450.00
Fixed expenses	
Interest on investment[2/] at 6%	35.62
License and taxes	51.31
Operating overhead and risk	20.00
Total fixed expenses per year	106.93
Fixed expenses per day (225 days per year)	.475
Depreciation of truck per day—life = 300 days	1.500
Total fixed expenses per day	1.975
Fixed expenses per hour (10-hour day) truck only	.198
Driver and 1.63 helpers, cost per hour	.789
Supervision per unit per hour	.043
Social Security and insurance 4% of labor cost	.033
Total fixed expenses per hour	1.063
Running expenses per mile—Woods or low-quality road	
Tires—life = 8,000 miles	.038
Gasoline—5 miles per gallon	.040
Oil and grease	.003
Repair labor	.003
Repair supplies	.003
Total	.087
Running expenses per mile—Graded dirt or better-quality road	
Tires—life = 15,000 miles	.020
Gasoline—9 miles per gallon	.022
Oil and grease	.003
Repair labor	.003
Repair supplies	.003
Total	.051

[1/] Cost of tires charged against running expenses.

[2/] Average investment = $\frac{\text{initial investment + trade-in value}}{2}$ + $\frac{\text{annual depreciation}}{2} = \frac{\$650.00 + \$200.00}{2} + \frac{\$337.50}{2} = \$593.75.$

Table 6.—Estimated costs per truck used for log hauling

	Dollars
Investment	
Truck complete with cab and dual wheels	950.00
Trailer complete with dual wheels	450.00
Gross investment	1400.00
Minus tires[1]—10 at $50	-500.00
Net investment	900.00
Minus trade-in value truck and trailer	-300.00
Amount to be depreciated	600.00
Fixed expenses	
Interest on investment[2] at 6%	47.81
License and taxes	51.31
Operating overhead and risk	20.00
Total fixed expenses per year	119.12
Fixed expenses per day (225 days per year)	.529
Depreciation of truck[3] and trailer[4] per day	1.750
Total fixed expenses per day	2.279
Fixed expenses per hour (10-hour day) truck only	.228
Driver, cost per hour	.300
Supervision per unit per hour	.043
Social Security and insurance 4% of labor cost	.014
Total fixed expenses per hour	.585
Running expenses per mile—Woods or low-quality road	
Tires—life = 8,000 miles	.062
Gasoline—4 miles per gallon	.050
Oil and grease	.003
Repair labor	.003
Repair supplies	.003
Total	.121
Running expenses per mile—Graded dirt or better-quality road	
Tires—life = 15,000 miles	.033
Gasoline—8 miles per gallon	.025
Oil and grease	.003
Repair labor	.003
Repair supplies	.003
Total	.067

1/ Cost of tires charged against running expenses.

2/ Average investment = Truck ($593.75—see table 5) + Trailer ($\left(\frac{\$250.00 + \$100.00}{2} + \frac{\$56.25}{2} = \$203.12\right) = \$796.87.$

3/ Life = 300 days.

4/ Life = 600 days.

per mile, or $0.291 per cord. In like manner, the cost of hauling over graded dirt roads was found to be $0.122 per mile of hauling distance, and the cost of hauling over gravel or hard-surfaced roads, $0.093 per mile.

By using the figures in table 7 it is very easy to compute the rate for any given haul. For example, on a haul of 5 miles in which there is 1.0 mile of woods road, 2.0 miles of graded dirt, and 2.0 miles of gravel road the total net cost per cord would be $2.089 (fixed cost) plus $0.291 (for the woods road) plus $0.244 (graded dirt road) plus $0.186 (gravel) or a total of $2.810.

Table 7.—Pulpwood production cost

Cost items	Net cost			Cost plus 10%		
	Per standard cord	Per 144 cu. ft. unit	Per 160 cu. ft. unit	Per standard cord	Per 144 cu. ft. unit	Per 160 cu. ft. unit
	Dollars					
Felling and bucking	1.412	1.588	1.765	1.553	1.747	1.942
Loading, unloading, and delay	.677	.677	.677	.744	.744	.744
Total fixed cost	2.089	2.265	2.442	2.297	2.491	2.686
Hauling per mile:[1]						
Woods road	.291	.291	.291	.320	.320	.320
Graded dirt road	.122	.122	.122	.134	.134	.134
Gravel or hard surface	.093	.093	.093	.102	.102	.102

[1] Round trip.

It must be remembered, however, that these figures are for net cost (including interest on investment in equipment) and that no allowance has been made for contractor's profit or risk. If 10 percent is allowed to cover this item in the foregoing example, the total becomes $3.091 per standard cord, and if 20 percent is allowed the total is $3.372 per standard cord.

Sawlog Production Costs

The sawlog production cost is also broken down into a fixed cost for the felling and bucking (page 3), skidding and loading (page 4), and loading, unloading, and delay (table 3), and a variable cost per mile depending upon the type of road (table 4). The two items for loading might be confusing. The first is the cost of the team and driver, who does the loading, and the second is the cost for the truck and driver while the loading is in progress. As has been shown, the cost of the felling and bucking for the logs produced during the study was $0.941 per M feet (Doyle-Scribner rule). The skidding and loading cost, including the employment of a swamper half time, was $1.104 per M feet; and the cost of the truck and driver while loading and unloading was $0.626 (1.07 hours at $0.585 per hour) per average load of 1,450 feet, or $0.432 per M feet (Doyle-Scribner rule).

The total fixed net cost, therefore, amounts to $2.477 per M feet (table 8) and applies regardless of the length of haul. For larger timber, however, these fixed costs would probably be lower, since large logs generally require less time per M feet than small ones to fell, buck, skid, and load. Conversely, for smaller timber fixed costs would probably be higher.

Table 8.—Cost per M feet[1] for sawlog production

Cost items	Net cost	Cost plus 10%
	Dollars	
Felling and bucking	.941	1.035
Skidding and loading	1.104	1.214
Loading, unloading and delay	.432	.475
Total fixed cost	2.477	2.724

[1] Doyle-Scribner rule.

Log hauling cost, like pulpwood hauling cost, varies depending upon the length of haul and the type of roads traversed. Furthermore, it will change also according to the volume per load. Since the size of the average log—and therefore of the average load—will vary considerably from one relatively small area to another, it is desirable to base the rates for hauling over the different types of road encountered upon size of the average log carried. This has been done in table 9. The volume of the average load carried when handling logs of different average sizes is also given in the table.

Table 9.—Cost per M feet[1] of hauling logs 1 mile[2] over three types of roads by average load

Average log	Average load	Type of road		
		Woods	Graded dirt	Gravel or hard surface
Board feet		Dollars		
60	1,060	.423	.205	.168
70	1,110	.404	.196	.160
80	1,160	.386	.188	.153
90	1,215	.369	.179	.146
100	1,265	.354	.172	.141
110	1,320	.339	.165	.135
120	1,370	.327	.159	.130
130	1,420	.315	.153	.125
140	1,470	.305	.148	.121
150	1,520	.295	.143	.117

[1] Doyle-Scribner rule.
[2] Round trip.

The method of computing the cost of hauling over the different types of roads (table 9) is the same as was used for computing the pulpwood costs. For example: It required 21.1 minutes (table 4) to traverse one mile round trip when traveling over woods roads, and this is equivalent to 0.352 hours. With the total fixed expenses per hour at $0.585 (table 6), the fixed cost for the hauling is $0.206 per load. In addition, the cost for running expenses when traveling over woods roads is $0.242 per mile round trip ($0.121 per mile one way). Thus, the total cost per mile for running plus fixed expenses while running is $0.448. For average loads of 1,450 feet the cost per M feet per mile is $0.448 divided by 1.450 or $0.309. The costs for loads of other average volumes were computed in a similar manner.

The same method has been used to compute the cost per round-trip mile when hauling over graded dirt and over gravel or hard-surfaced roads. Thus, on a given haul over 1 mile of woods road, 2 miles of graded dirt road, and 2 miles of gravel road with the logs averaging 140 feet each the total cost would be $2.477 plus $0.305 plus $0.296 plus $0.242, equaling $3.320 per M feet, Doyle-Scribner rule. As was mentioned in the discussion of pulpwood costs, these figures are net costs (including interest on investment) and do not allow anything for profit and risk. If this is figured at 10 percent, the cost of the haul in the example becomes $3.652. If the allowance is 20 percent above net cost, the total becomes $3.984 per M feet.

Application of Results to Other Conditions

It is realized that cutting and hauling conditions, timber size, and trucks and equipment undoubtedly will vary from one locality to another. The information as given, therefore, cannot and should not be applied in any given area in the South without checking with actual conditions as found in the locality. The data obtained in this study have been presented in such form that these adjustments can easily be made. For instance, if truck or labor cost is greater or less than that given, the estimated hourly (or hourly and per mile) rates can be adjusted accordingly, and the new rates applied to the time figures presented in the report. If the volume per load of logs should be greater or less than that given, the only adjustment that need be made is to divide the cost per round trip by the new volumes to obtain the adjusted cost per M feet.

However, it can be readily seen that in practically all cases these adaptations are not half so important as the adjustment of contract rates for different types of roads. With the rates constant regardless of types of roads over which the hauling is done, one contractor may "go broke" hauling 5 miles on all-woods road, whereas a second trucker may make good money hauling the same distance on good gravel or hard-surfaced road.

If the volume to be hauled over a given route is roughly known, these data can also be used as a basis for determining whether construction of a graded dirt road is justified in places where only woods roads are available, or whether it will pay to improve a graded dirt road by graveling.

OCCASIONAL PAPER NO. 97 NOVEMBER 8, 1940

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

INCREASED NAVAL STORES PRODUCTION FROM CHEMICALLY TREATED STREAKS

By

T. A. Liefeld
Associate Silviculturist
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration official project 65-2-64-74.

INCREASED NAVAL STORES PRODUCTION FROM CHEMICALLY TREATED STREAKS

By T. A. Liefeld, Associate Silviculturist
Southern Forest Experiment Station

Application of a chemical reagent to the freshly chipped streak is one of the most promising recent developments for increasing gum naval stores yields. Present market conditions do not favor expanded production, but producers should welcome the opportunity offered by this new technique to cut production costs. Some operators may thereby find aid in solving problems caused by continued low market quotations for turpentine and rosin. Apparently originating in Germany about 1933, the idea of chemical stimulation has received increasing attention there and in Russia.1/ A large number of chemicals has been tested. Yield increases of 100 to as much as 250 percent have been reported, but most of the reports are conflicting. There is general agreement, however, that double streaks, i.e., streaks approximately twice as high as normal, must be removed at each chipping in order that increased yields may be maintained, particularly if strong acid solutions are used.

Because of the apparent possibilities for chemical treatment in this country, the Southern Forest Experiment Station, in cooperation with the Bureau of Agricultural Chemistry and Engineering (formerly Bureau of Chemistry and Soils), conducted a small exploratory test on the Olustee Experimental Forest in 1936 to determine the advisability of more thorough study. The conclusions drawn were that (1) yield can be stimulated by applying chemical reagents to the streak, (2) with some chemicals, or at least with certain concentrations, it may be necessary to remove more wood than is required for untreated streaks, and (3) further study was justified. Accordingly, a more intensive study was conducted during 1938.

Materials and Methods

To keep the experiment within the limits of available manpower, it was necessary to select as carefully as possible the reagents most likely to show promise. On advice of chemists and plant physiologists sulphuric acid, acetic acid, and washing soda were chosen in order to have represented an active inorganic acid, an active organic acid, and an active alkali. A relatively weak (5%) and a relatively strong (20%) solution of each reagent in distilled water were selected. In order to determine, within the limits of practical application, how much wood must be removed to maintain prospective increased yields, a range of streak heights was applied.

A total of 168 second-growth pines—84 longleaf and 84 slash—were selected early in April 1938. Galvanized cups and tins were installed and 4 streaks were chipped, 1/2 inch high and 1/2 inch deep, at weekly intervals

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1/ Kublun, H. Turpentining pines with chemical reagents. 64 pp., illus. J. Neumann, Neudamm. 1936. (In German.)
Nikolaev, N. F. and M. A. Sinelobov. The influence of chemicals on gum yields. Forest Chemical Industry 6: 4-9. (In Russian.)

during that month. Total gum yield was weighed on a balance scale to the nearest gram for each tree and streak. With these yields as a basis, the trees were divided into equal-yielding groups of 4 trees each. Treatments were begun with the fifth streak on May 4 and continued without interruption for 30 consecutive weekly chippings until November 23. Individual tree yields were obtained for each streak throughout the duration of the study. Maximum air temperatures on the days of chipping were recorded so that allowance could be made for the effect of temperature on gum yield. The tests included all possible combinations of (1) species (longleaf and slash pine), (2) height of streak (1/4 inch, 5/8 inch, 1 inch), and (3) chemical reagents (5 and 20 percent solutions of sulphuric acid, acetic acid, and washing soda; and no reagent, or check). Depth of streak was uniformly 1/2 inch, regardless of treatment.

Effect of Chemical Treatments on Gum Yield

The average yield per streak produced by each of the 4-tree groups during the 30-streak period of treatment is presented in table 1. From the standpoint of practical application, the most significant comparisons within the table are: (1) Slash pine chipped 5/8 inch high produced 67 percent more gum with the aid of 20% sulphuric acid than without it, and (2) longleaf pine chipped 1 inch high produced 27 percent more when similarly treated. The 5% sulphuric acid solution was not effective except on 1-inch streaks, but with this height of streak the 20% solution proved almost twice as beneficial. Both concentrations of acetic acid proved, with almost no exceptions, to be practically worthless as stimulants. Almost all of the washing soda treatments increased yields, but the gains were hardly sufficient to offset the cost of application.

Commercial Possibilities of 20% Sulphuric Acid Treatment

Because 20% sulphuric acid was the only reagent tested that was found to have commercial possibilities, a more detailed analysis of this treatment was made to bring out in greater detail the effect of streak height in combination with the acid. Results of this analysis are presented in figure 1, which shows for both longleaf and slash pine the net trends of the yields during the course of the experiment for the three heights of streak employed. Effect of temperature was largely accounted for and removed by the multiple regression method of analysis.

It is evident from the chart that height of streak is an important consideration in connection with acid application, at least with stronger acid solutions such as 20% sulphuric acid. A streak height of 1/4 inch is not adequate to maintain increased yields beyond relatively few chippings: the yields of the slash pine group rose considerably immediately after acid treatment was begun (at streak number 5) but began to decline after about 10 streaks had been treated (at about streak number 15). From then on until the end of the year the acid-treated group actually produced somewhat lower yields than the no-acid group. As a result there was no significant difference between the average yields of the acid and no-acid treatment for the entire 30-streak treatment period. For the longleaf pine groups, chipped 1/4 inch high, on the other hand, there was actually a significant difference in

Table 1.—Effect of chemical treatments on gum yield

Height of streak and reagent	Slash pine			Longleaf pine		
	Average yield per streak 1/	Comparison with check-tree yields		Average yield per streak 1/	Comparison with check-tree yields	
		Increase	Decrease		Increase	Decrease
	Grams	Percent	Percent	Grams	Percent	Percent
1/4 inch:						
No treatment	428	..	..	306	..	..
5% sulphuric acid	353	..	18	262	..	14
20% sulphuric acid	462	8	..	207	..	32
5% acetic acid	364	..	15	248	..	19
20% acetic acid	440	3	..	220	..	28
5% washing soda	369	..	14	326	6	..
20% washing soda	407	..	5	318	4	..
5/8 inch:						
No treatment	431	..	..	344	..	..
5% sulphuric acid	403	..	6	298	..	13
20% sulphuric acid	720	67	..	328	..	5
5% acetic acid	372	..	14	290	..	16
20% acetic acid	438	2	..	282	..	18
5% washing soda	486	13	..	374	9	..
20% washing soda	435	1	..	353	3	..
1 inch:						
No treatment	422	..	..	357	..	..
5% sulphuric acid	528	25	..	393	10	..
20% sulphuric acid	591	40	..	455	27	..
5% acetic acid	486	15	..	276	..	23
20% acetic acid	417	..	1	327	..	8
5% washing soda	472	12	..	428	20	..
20% washing soda	481	14	..	421	18	..

1/ Averages for test groups of 4 trees during 30-streak treatment period.

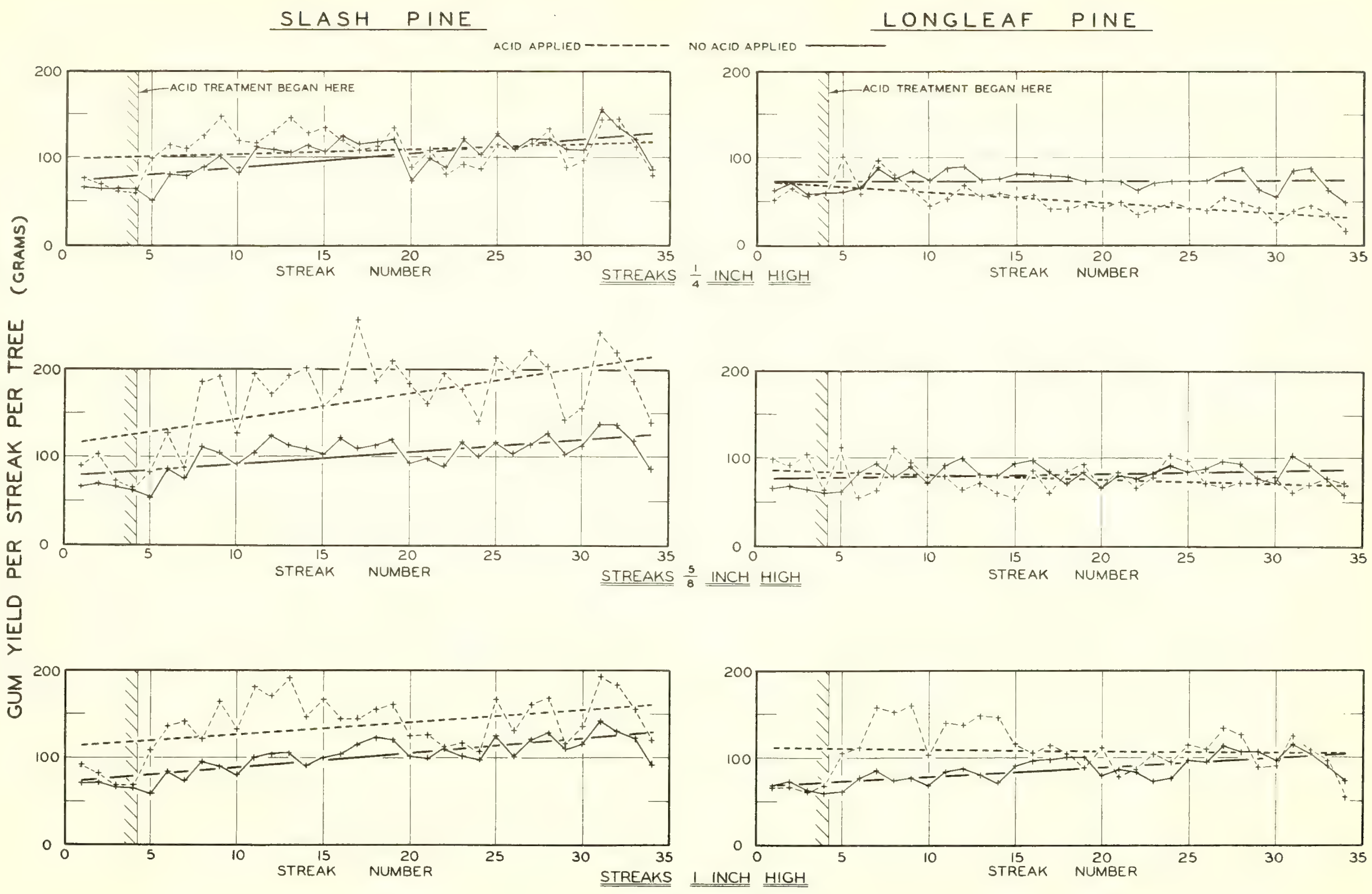

FIGURE 1.— NET TRENDS OF GUM YIELD (EFFECT OF TEMPERATURE PARTIALLY REMOVED) BY SPECIES, STREAK HEIGHT, AND REAGENT TREATMENT.

favor of the no-acid treatment. With streaks 5/8 inch high the acid-treated slash pine produced and maintained significantly higher yields than the no-acid group, whereas there was no difference between the two longleaf pine groups. With a 1-inch height of streak slash pine still responded favorably to acid application, but the yields from the acid treatment again began to decline during the latter half of the period, indicating that this height of chipping removed more wood than necessary for sustained optimum yields. For longleaf pine, however, the 1-inch streak height proved more desirable than either 1/4- or 5/8-inch in that it produced a significant difference in favor of acid treatment. The charts for longleaf pine indicate, moreover, that even 1-inch streaks were not sufficient to maintain increased yields for the duration of the season and that greater yield differences might have been obtained from the acid treatment if more than 1 inch of wood had been removed at each streaking. But it is doubtful that acid application would be of value in commercial practice if more than a double streak must be chipped. The labor of triple streaking would be at least double that of chipping a single streak. From the data on longleaf pine at hand, it seems highly improbable that triple streaking with acid treatment would result in increasing the yield to twice that obtained from a single untreated streak.

One of the most important points brought out by the study is that longleaf and slash pine do not react alike to chemical reagents. The yield from slash pine was increased when 20% sulphuric acid, the most effective reagent, was applied to streaks chipped either 1/4, 5/8, or 1 inch high. Longleaf pine streaks, however, chipped 1/4 and 5/8 inch high and similarly treated, produced less gum than untreated streaks. Only when chipping was 1 inch high was it possible to increase yields from this species. Until further chemicals are tested, therefore, it appears that chemical stimulation holds greater promise for slash pine. These preliminary investigations indicate that yield increases up to 67 percent can be expected from stands composed predominantly of this species when streaks are chipped approximately 1/2 inch high and a 20% sulphuric acid solution is applied to the streak immediately after chipping. In longleaf pine stands, on the other hand, it will be necessary to chip streaks 1 inch high in order to obtain increases of yields up to only 27 percent.

The chemical solution is made by pouring one pint of concentrated (95%) commercial grade sulphuric acid, obtainable at most drug stores for about 20 cents a pint, into a gallon of distilled or rain water.[2] The acid should be poured into the water (never the water into the acid) and mixed thoroughly by stirring in an earthenware or glass vessel. The solution should not be stored in a metal container; it will corrode the metal in time. Care should be exercised in handling the solution, for it may injure the eyes or clothing. It is not injurious to the hands. A chipper can carry a bottle of the solution in his hip pocket and daub it on the fresh streak with a dauber made by wrapping a small soft cloth around a stick.

In a series of laboratory tests the Bureau of Agricultural Chemistry and Engineering has been unable to discover any chemical or physical changes in the gum or its products, turpentine and rosin, caused by the application of chemical reagents to the streak. Moreover, galvanized cups and tins are

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2/ Chemical concentrations are commonly based on weight rather than on volume. The procedure described results in a solution (by weight) of approximately 20%.

not seriously affected by the 20% sulphuric acid solution, probably because of a combination of the following circumstances: (1) Only a small amount of solution is required for each streak, (2) rain water, which is present in cups much of the time, dilutes the solution considerably, and (3) the solution is quickly absorbed by the wood of the fresh streak.

Summary

Chemical reagents applied to the fresh streak offer considerable promise of increasing gum naval stores yields. The experiment described in this paper tested six reagents (5 and 20% solutions of sulphuric acid, acetic acid, and washing soda) applied to 1/4-, 5/8-, and 1-inch streaks on slash and longleaf pine. The 20% sulphuric acid treatment applied to streaks 5/8 inch high increased yields from slash pine 67 percent, whereas on longleaf pine it was necessary to chip streaks 1 inch high in order to maintain yields 27 percent greater.

These preliminary investigations indicate that gum production from stands which are predominantly slash pine can be stimulated by daubing 20% sulphuric acid on the fresh streak chipped approximately 1/2 inch high. Unless the operator has only the largest immediate return to consider, because he is planning to cut the trees after several seasons of turpentining, the acid treatment does not appear profitable for use in longleaf pine stands.

OCCASIONAL PAPER NO. 98 JANUARY 17, 1941

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SOUTHERN FOREST EXPERIMENT STATION

E. L. Demmon, Director

New Orleans, La.

FIRST-YEAR SURVIVAL AND HEIGHT GROWTH OF COTTONWOOD PLANTATIONS AT STONEVILLE, MISS.

By

Henry Bull, Silviculturist
and
J. A. Putnam, Associate Forester
Southern Forest Experiment Station

In cooperation with
Delta Experiment Station, Stoneville, Miss.

The major portion of this study was carried on in cooperation with the Mississippi Agricultural Experiment Station under the Cooperative Farm Forestry Act of 1937.

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Introduction

Most cut-over forest land in the bottomland hardwood region does not need to be planted to obtain another stand of timber. Natural reproduction usually is satisfactory in amount, although often predominated by relatively undesirable species. Cut-over areas that do need planting, however, are not uncommon. Very heavy cutting and repeated severe fires are largely responsible for this condition, but heavy overgrazing may also be a factor. Typical bottomland areas in need of planting support a scanty or negligible stand of low-grade and cull trees, and a very dense, tangled ground cover of weeds, brush, and vines. Since fast-growing trees are most likely to be successful in overcoming this severe competition, cottonwood is obviously an excellent prospect for planting. Fast-growing trees may produce somewhat less desirable and less valuable wood for some purposes than trees with slower growth rates, but on bottomland planting sites it may be a case of fast-growing trees or failure. Cottonwoods will yield merchantable pulpwood, or later sawlogs, in a comparatively short period. They will also shade out the dense ground cover and thus facilitate the later establishment of more slowly growing tree species, some of which may be of greater intrinsic value.

Besides general interest in the suitability of cottonwood for planting on most unstocked bottomland sites, there is special interest in the planting of cottonwood on Mississippi River batture lands (i.e., lands between the levee and the river) to replace mature cottonwood after logging. Cottonwood is always replaced by a number of other hardwood species after logging, and new cottonwood stands originate only on bare land deposited by a river or abandoned by farmers. Since the species that replace cottonwood frequently are much less valuable, it is desirable to obtain another stand of cottonwood either by measures that will favor natural reproduction or by planting. For either course, there is very little information available on suitable methods or probable results.

Cottonwood Planting Experiments at Stoneville, Miss.

Location and History. A cooperative forest research program was begun by the Southern Forest Experiment Station and the Mississippi Agricultural Experiment Station in October 1939, with local headquarters at the Delta Experiment Station, Stoneville, Miss. The object of this program is to conduct research on important forestry problems in the bottomland hardwood region. A typical cut-over forest of 2,580 acres, owned by the State, is available at Stoneville for demonstration and research, and two research projects are now in progress on this forest. One project, concerned with improvement cuttings, has been reported in a previous paper.[1] The other project, concerned with the planting of cottonwood, is reported here.

Experimental plantations of cottonwood cuttings and seedlings were established at Stoneville between January 30 and April 26, 1940. The plantations were examined June 18 - 21, 1940, to determine the early survival, and October 4 - 12, 1940, to determine the first-year survival and height growth. A report on the June examination was made in an earlier publication.[2] The present paper is a report on the October examination. Results obtained from the plantings of hybrid poplars are inconclusive thus far and are not further discussed in this report.

Purpose. The cottonwood planting study was designed to determine (1) whether cuttings or seedlings make the better planting stock, and (2) the effects of different planting sites, dates of planting, depths of planting and lengths of cuttings, and top-pruning treatments of seedlings. Supplementary information also was obtained on the characteristics of the most successful cuttings and seedlings, the effect of a single partial release from competition, the effect of using a rabbit repellent, and the growth of cuttings in the nursery.

There have been few previous studies of forest planting in the Delta; hence there was little background of experience for the present study. Valuable advice was obtained, however, from Mr. R. D. Stevens, of the Department of Horticulture and Forestry, University of Arkansas, who had recently made experimental cottonwood plantings in the Delta region of Arkansas.

Planting Sites. Two experimental plantations were established. One plantation occupies a well-drained "flat" that supported bottomland red oak, overcup oak, water hickory (bitter pecan), American elm, and other bottomland species. The other plantation is divided by a shallow slough into a "ridge" and a shallow swamp. The ridge site is higher than the flat, and once supported such species as redgum[3] and water oak. The swamp supported baldcypress, waterlocust, swamp privet,[4] and other swamp species, and was intermittently under water or waterlogged throughout the planting period. The flat is too wet in the spring for profitable agricultural use except in unusually dry years. The ridge is fair to good farm land, but the area is small and relatively inaccessible. The swamp is entirely unfit for farming, even though there is a large drainage canal within a quarter-mile.

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[1] Putnam, J. A., and Henry Bull. Improvement cuttings in the bottomland hardwood forests of Mississippi. Occasional Paper No. 93. Sou. For. Expt. Sta. Oct. 22, 1940.

[2] Bull, Henry, and J. A. Putnam. Early survival of cottonwood and hybrid poplar plantations at Stoneville, Miss. Occasional Paper No. 94. Sou. For. Expt. Sta. Oct. 4, 1940.

[3] The common name recently accepted by the Forest Service for Liquidambar styraciflua is sweetgum.

[4] Similarly, Forestiera acuminata is common adelia.

To provide more uniform conditions for experimental purposes, and to facilitate the planting and later examinations, the largely low-grade and cull trees on the flat were girdled, and the sparse stand of similar trees on the other two sites was clear cut. On the flat the planting was done in narrow lanes cut through the dense brush, weeds, and vines with "Kaiser" blades (large ditch-bank blades or brush hooks). On the other two sites the entire planting area was cleared with Kaiser blades after the trees were removed. The brush, weeds, and vines sprouted vigorously in the spring and were 2 to 5 feet high in mid-June.

All three sites have heavy clay soils, whereas natural stands of cottonwood along river margins usually are on very much lighter soils that range from very fine sands to fine sandy loams. Cottonwood has been observed to grow well on almost any soil type in the Delta when once established, but the extent to which soil type affects establishment is not known. The most obvious reason why cottonwood usually is not abundant except along river margins is that moist, bare soils are seldom found elsewhere. Cottonwood seed is exceptionally light, fluffy, and perishable; it cannot reach the ground at all if vegetation is present, and after reaching the ground it must have continuously plentiful moisture to germinate and grow. Heavy clay soils usually do not occur along river margins, and seldom are moist and bare at the same time on cut-over lands. A few cottonwood cuttings were planted in Deer Creek fine sandy loam in the horticultural nursery at the Delta Experiment Station in March 1940, and although their survival was only slightly better than that of cuttings on the heavy clay of the cut-over land, their height growth was some 8 to 15 times greater. Since the cuttings in the nursery were cultivated several times and had no competition from other vegetation, the effect of soil type alone cannot be evaluated.

Since there is no conclusive evidence as to the relative advantages of heavy clay soils and much lighter soils in enabling cottonwood cuttings and seedlings to root themselves, the application of the results of the present study to much lighter soils is not known. It is thought, however, that the results would be at least as good—and probably better in an abnormal year like 1940—on lighter soils that contain much silt or fine sand and retain considerable moisture well into the summer. Results probably would be poorer on coarse sands that dry out rapidly during the summer.

Planting Stock and Methods. Cuttings from native cottonwood (Populus deltoides virginiana) were taken with pruning shears from vigorous 1-year-old shoots in the middle and upper parts of freshly felled trees in stands between the levee and the Mississippi River near Greenville, Miss. The trees were mostly 2 to 8 inches in diameter, although a few were as large as 12 inches in diameter. "Fresh" cuttings were planted within 2 to 4 days after they were obtained, being heeled into the ground or stored in shallow water in the meantime. "Stored" cuttings were kept in cold storage at a temperature of about 35° F. between the time of preparation (March 4) and that of planting. Four different lengths of cuttings, two depths of planting for each length of cutting, and three dates of planting were tested with fresh cuttings. A single length of cutting and depth of planting at three different planting dates were tested with stored cuttings.

On the flat, the planting was done from January 30 to February 2, when cottonwood buds were completely dormant. On the other two sites the plantings included one while the cottonwood buds were still dormant (March 6 - 8 and 11), one at the time the buds were beginning to open (March 25 - 27), and two after the buds had opened in the woods (April 15 - 17 and 26). All cuttings were set in holes made with cylindrical planting bars. Bars of various diameters from 1/4 to 7/8 inch were used, depending on the diameters of the cuttings. An effort was made to obtain a tight fit for each cutting, and contact between the base of each cutting and the bottom of the hole.

Cottonwood seedlings were obtained from nearby ditches and borrow pits[5/] for planting on the flat, and from stands between the levee and the Mississippi River for the other two sites. Seedlings 1½ to 7 feet high and mostly 2 years old were selected and pulled up without any digging. They were then planted, after just enough trimming of the roots to permit placing in holes made with the same planting bars used for the cuttings. The tops of some seedlings were left unpruned, while others were cut back to 2, 4, or 18 - 24 inches. Both fresh and stored seedlings were planted, the former at the same dates as the cuttings, but the latter on April 26 only.

Spacings of both 6 x 6 and 8 x 8 feet were used, but the results to date are most probably not affected by spacing.

Special Observations and Treatments. Certain obvious physical characteristics and measurements of the cuttings and seedlings planted on the flat were recorded for each plant, since it seemed likely that some item of appearance or size might be closely related to survival and growth. The data and the results are discussed in sections 3 and 5 under "Results."

After completing the planting on the flat, half of each test was treated with a rabbit repellent as a precaution against possible damage. The composition of the repellent and the interesting but unexpected results produced are discussed in section 12 under "Results."

In early June, the competing vegetation was so dense and tall that it was thought possible that certain tests might prove successful only if the cottonwood plants were at least temporarily and partially released from this severe competition. Half of each test on each site was therefore released. The character of the release and the results obtained are discussed in section 7 under "Results." Comparisons of released and unreleased stock are also mentioned in other sections.

[5/] Source of material for levees or roads.

Unusual Growing Conditions and Insect Damage. At Stoneville the winter of 1939-40 was exceptionally cold and dry. The swamp was not flooded at all during this season immediately preceding planting. Conditions suitable for plant growth in the spring came into being about 3 weeks later than usual; it was unusually cool and wet until well into June, and unusually wet for a month longer. The ground remained cold and soggy long after the cottonwoods had fully developed leaves, and heavy rains flooded the swamp three times during March and April. All existing local records were broken by a very late killing frost, on April 13, and by heavy rainfall during late June and early July that flooded parts of the swamp to a maximum depth of 5 feet and resulted in standing water over most of the swamp for a period of about 10 days. Rains and floods of this nature are common in the region in January, but previously unrecorded in July. From the middle of July until November there was very little rain, and temperatures were normal or above normal. It is impossible to say exactly what effect these very unusual conditions had on the survival of the experimental plantings, but it seems certain that the conditions were unfavorable, especially to cuttings, because of their lack of roots when planted.

Insect damage was unusually widespread during the growing season, and at least three species of insects had a part in it. Poplar beetles were prevalent very early in the spring, then disappeared in May after defoliating relatively few plants. These beetles probably caused no actual mortality, but helped to weaken many individual plants. Later in the summer small, gray, woolly caterpillars became very numerous and defoliated a large proportion of the plantings. These caterpillars, which seemed to feed only on cottonwood and willow, defoliated many trees more than 50 feet tall. Local residents do not recall any previous attack of similar severity. In the plantations the caterpillars seemed to prefer the tallest, most vigorous, and most conspicuous plants and completely defoliated most of them. This injury occurred late in the season and it is doubtful that it caused any mortality. Grasshoppers caused considerable damage by chewing off patches and sometimes complete bands of bark. Such scars might have been mistakenly ascribed to mice or rabbits, except that they were usually found at heights to which these animals could not reach. Grasshoppers killed a few apparently well-rooted plants by girdling them, and caused much additional damage by chewing out terminal buds and girdling terminal shoots, which results in forked or crooked trees.

Analysis of Data

The plantations were planned and arranged in the field according to modern statistical techniques of replication and randomization, with four blocks on each site. A detailed analysis of variance to determine the statistical significance of the various survival percentages and average heights could be made, but is considered unnecessary. The study is exploratory and the main interest is in the larger, consistent differences that hardly need statistical measures of significance. Moreover, some small or inconsistent differences need further testing on a larger scale or in other years regardless of whether or not they are statistically significant in the present study. The results discussed below are based on a study of the size and consistency of survival percentages and average heights, and involved many separate tabulations to bring out desired comparisons. Even large differences would of course have doubtful significance in the absence of proper replication and randomization; hence, the field arrangement has proved indispensable.

Results

For each test, the number planted and the percentages alive in June and in October are recorded in tables 1, 2, and 3. A complete examination was made in June, but in October the tests that it was thought would show less than 10 percent survival were not examined. The tests not completely examined in October are considered too poor for further study. Identification of the tests showing these unsatisfactory results was made from the records of the June examination, supplemented by an October examination of representative borderline cases. Table 4 lists the more successful planting stock for each site and planting date.

Table 1.—Summary of survival in June and in October 1940 of all cottonwood plantings made January 30 - February 2, 1940

Site: flat

Class of stock	Length of cutting	Depth of planting	Alive in June	Alive in October		Stock planted
				Not released	Released	
	- - - Inches	- - -		- - Percent	- -	Number
Fresh cuttings:						
Terminal[1]	12	9	57	3	12	44
Nonterminal	12	9	45	5	20	44
Terminal	16	12	51	14	28	43
Nonterminal	16	12	50	11	50	44
Terminal	20	15	47	16	35	43
Nonterminal	20	15	53	19	44	43
Fresh seedlings:						
Top cut back to 2 inches			84	41	41	44
Not cut back			68	18	58	44

[1] A terminal cutting is one made from the end of a shoot, including the last or terminal bud.

Table 2.—Summary of survival in June and in October 1940, of unreleased cottonwood cuttings planted March 6 - April 26, 1940[1]

Kind of cuttings	Length	Depth of planting	Site[2]	Date of planting and dates of examination								Cuttings planted at each date
				Mar. 6-8		Mar.25-27		Apr.15-17		April 26		
				June	Oct.	June	Oct.	June	Oct.	June	Oct.	
	- Inches -			- - - - - - - - - Percent - - - - - - - - -								Number
Fresh	10	6	R	17	-	18	-	3	-			99-100
	10	6	S	28	-	35	-	19	-			97-99
	10	8	R	35	9	44	9	0	-			100
	10	8	S	30	-	42	-	4	-			83-89
	20	12	R	54	23	36	19	[illegible]	-			99-100
	20	12	S	55	0	35	-	3	-			99-100
	20	16	R	64	26	53	31	7	-			100
	20	16	S	26	0	29	0	3	-			97-100
	40	15	R	33	18	17	-	1	-			100
	40	15	S	37	7	30	[illegible]	6	-			99-100
	40	20	R	53	24	27	15	1	-			100
	40	20	S	36	3	23	0	15	-			100
	60	18	R	24	0	10	-	2	-			50
	60	18	S	40	18	14	-	6	-			50
	60	24	R	32	6	16	-	4	2			49-50
	60	24	S	38	22	8	-	32	12			49-50
Stored	20	16	R			71	27	53	13	53	2	100
	20	16	S			35	0	55	2	54	0	98-100

[1] In this and subsequent tables, a short dash (-) in a data column indicates that no data were recorded. See explanation under "Results," page 6.

[2] R = ridge; S = swamp.

Table 3.—Summary of survival in June and in October 1940, of unreleased cottonwood seedlings planted March 11 - April 26, 1940

Kind of seedlings	Length after cutting back	Site[1]	Date of planting and dates of examination								Seedlings planted at each date
			Mar. 11		Mar.25-27		Apr.15-17		April 26		
			June	Oct.	June	Oct.	June	Oct.	June	Oct.	
	Inches		- - - - - - - - Percent - - - - - - - -								Number
Fresh	4	R	88	44	92	12	8	-			12-25
	4	S	80	24	75	0	25	12			11-25
	18 - 24	R	80	24	69	36	15	-			13-25
	18 - 24	S	88	64	85	68	15	0			13-25
	n.c.b.[2]	R	64	9	88	52	4	-			25-50
	n.c.b.	S	46	26	52	-	8	-			25-50
Stored	4	R							83	33	12
	4	S							92	18	12
	18 - 24	R							69	0	13
	18 - 24	S							100	40	13
	n.c.b.	R							48	0	25
	n.c.b.	S							84	42	25

[1] R = ridge; S = swamp.

[2] Not cut back.

Table 4.—Planting stock having best first-year survival, grouped according to site and planting date. All plantings having at least 18 percent survival are listed.

Site	Planted March 6 - 8 and 11			Planted March 25 - 27			Planted April 26		
	Kind of stock[1]	Survival		Kind of stock[1]	Survival		Kind of stock[1]	Survival	
		Not re-leased	Re-leased		Not re-leased	Re-leased		Not re-leased	Re-leased
		Percent			Percent			Percent	
Ridge	Fresh sdlgs. 4"	44	60	Fresh sdlgs. Uncut	52	44	Stored sdlgs. 4"	33	33
	Fresh ctgs. 20 - 16"	26	26	Fresh sdlgs. 20"	35	41			
	Fresh sdlgs. 20"	24	64	Fresh ctgs. 20 - 16"	31	39			
	Fresh ctgs. 40 - 20"	24	38	Stored ctgs. 20 - 16"	27	27			
	Fresh ctgs. 20 - 12"	23	31	Fresh ctgs. 20 - 12"	19	23			
	Fresh ctgs. 40 - 15"	18	20	Fresh sdlgs. 4"	18	61			
Swamp	Fresh sdlgs. 20"	64	80	Fresh sdlgs. 20"	68	70	Stored sdlgs. Uncut	42	51
	Fresh sdlgs. Uncut	26	42	Fresh sdlgs. Uncut	44	52	Stored sdlgs. 20"	40	75
	Fresh sdlgs. 4"	24	40						
	Fresh ctgs. 60 - 24"	23	25						
	Fresh ctgs. 60 - 18"	18	26						
	Planted January 30 - February 2								
Flat	Fresh sdlgs. 2"	41	41						
	Fresh ctgs. NT, 20 - 15"	19	44						
	Fresh sdlgs. Uncut	18	58						

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[1] The figures following "sdlgs" (seedlings) represent the height in inches to which they were cut back after planting. The figures following "ctgs" (cuttings) represent the length and the depth of planting, respectively, each in inches. NT = Nonterminal.

The principal results contained in the foregoing tables and in other data obtained in the study are discussed below in short, numbered sections. This method of presentation seems desirable in view of the large number of variables to be considered, and facilitates reference to the different topics. Survival percentages mentioned below are for unreleased plants unless specifically noted otherwise.

1. Seedlings vs. cuttings. In general, seedlings showed much higher survival than cuttings. Table 5 gives the best individual survival percentages for each class of stock for the different sites.

Table 5.--Comparison of best results for seedlings and cuttings, in survival percent, classified according to planting site

Site	Fresh stock		Stored stock	
	Seedlings	Cuttings	Seedlings	Cuttings
Ridge	52	31	33	27
Flat	41	19		
Swamp	68	22	42	2

2. Time of planting. Plantings of fresh seedlings during the dormant period, and at the time cottonwood buds were beginning to open, resulted in approximately the same survival. Fresh cuttings, however, showed slightly better survival when planted during the dormant period than when planted at the time the buds were beginning to open. The two different dates of planting within the dormant period gave equally good results for both classes of stock. In marked contrast, plantings of fresh stock 2 to 3 weeks after the buds had opened were complete or almost complete failures.

Planted at the time the buds were beginning to open, fresh cuttings showed slightly higher survival than stored dormant cuttings of the same depth of planting and length. The fresh cuttings planted 2 to 3 weeks after the buds opened, however, had slightly lower survival. The stored cuttings that were planted at the time the buds were beginning to open showed best survival, those planted 2 to 3 weeks later poorer survival, and those planted 4 weeks later poorest survival.

The data indicate clearly that planting should be done during the dormant period, not later than the time the buds begin to open. If for any reason planting must be done later, stored dormant stock is preferable and should be planted as early as possible in the growing season.

3. Characteristics of the most successful seedling stock. The length of the top and the length of the roots at the time of planting were measured and recorded for the 88 seedlings planted on the flat. Records also were kept of the seedlings cut back to about 2 inches soon after planting. Root lengths varied from 3 to 14 inches and averaged 8 inches. The original top lengths varied from 19 to 82 inches and averaged 45 inches. The seedlings planted on the other two sites were not measured, but probably averaged about

4 inches more in root length and about 10 inches more in original top length. Their survival was somewhat better than that of the seedlings on the flat, indicating that the larger seedlings are better planting stock. Analysis of data for the measured seedlings indicates that the stock with the longer roots showed distinctly the better survival regardless of the length of the original top and regardless of whether or not the top was cut back. The 20 seedlings with roots at least 10 inches long showed 55 percent survival, whereas the 68 seedlings with shorter roots showed only 37 percent survival. Root length was by far the most important single factor measured.

4. Cutting back of seedlings vs. no cutting back. Table 6 shows how the effect of cutting back seedlings immediately after planting varied with the site and with the time of planting.

Table 6.—Percentages of survival in October for unreleased seedlings, classified according to cutting-back treatment, site, and time of planting

Site	Time of planting[1]	Cut back to 2-4 inches	Cut back to 18-24 inches	Not cut back
Ridge	Complete dormancy	44	24	9
	Buds opening	18	35	52
	Leaves out[2]	54	0	0
Swamp	Complete dormancy	24	64	26
	Buds opening	0	68	44
	Leaves out[2]	18	40	42
Flat	Complete dormancy	41		18

[1] Phrases in this column refer to condition of nearby large cottonwoods.

[2] Stored stock was used at this time.

In the swamp, seedlings cut back to 18 - 24 inches generally showed highest survival, and those cut back to 4 inches lowest survival. On the ridge, however, highest survival was obtained either with seedlings cut back to 4 inches, or with seedlings not cut back, depending on the time of planting. These results indicate that cutting back improves survival when the plant cannot begin growth immediately, or when the supply of moisture is not abundant.

5. Characteristics of the most successful cuttings. The kind (terminal or nonterminal), diameter class, and numbers of large and of small buds were recorded for each of the 264 cuttings planted on the flat. Terminal cuttings (those made from the ends of shoots, including the last or terminal buds) showed the same survival as nonterminal cuttings where there was no release from competition, but consistently lower survival where released. This is shown in table 7, adapted from table 1.

Table 7.—Percentages of survival in October for fresh cuttings planted on the flat, classified by release treatment and kind of stock

Kind of stock	Not released	Released
12-inch cuttings:		
Terminal	3	12
Nonterminal	5	20
16-inch cuttings:		
Terminal	14	28
Nonterminal	11	50
20-inch cuttings:		
Terminal	16	35
Nonterminal	19	44
All lengths:		
Terminal	12	21
Nonterminal	12	36

The table also shows that survival increased with length regardless of whether or not the cuttings were released. On the other two sites, the best lengths were found to be 20 and 40 inches on the ridge, and 60 inches in the swamp (see next section).

For a given length and kind of cutting (terminal or nonterminal), diameter or thickness apparently did not affect survival. The numbers of large and of small buds on a cutting showed no strong or consistent relationship to survival.

6. Depth of planting and length of cuttings in relation to site. Table 8 shows the best survival percentages for different depths of planting and lengths of fresh cuttings on the ridge and in the swamp.

Table 8.—Best October survival percentages for fresh cuttings of various lengths, grouped by site and mode of planting

Length of cutting (inches)	Ridge		Swamp	
	Shallower planting	Deeper planting	Shallower planting	Deeper planting
10	0	9	0	0
20	23	31	0	0
40	18	24	7	3
60	0	6	18	22

It is evident that 20- and 40-inch cuttings are best on the ridge, and that 60-inch cuttings are best in the swamp. The failure of short cuttings in the swamp probably is due largely to the smothering competition of dense weeds at the time the cuttings were trying to get rooted. Seedlings in the swamp, even though they had roots to start with, showed their poorest survival when most severely cut back.

Relatively deep planting produced the better results on the ridge, but in the swamp the effect of different depths of planting is indefinite.

7. Effect of a single partial release from competition in June. A single partial release from competition was accomplished by "chopping" away competing vegetation around each plant with a cotton-chopping hoe to a radius of about 1-1/2 feet in half of the rows devoted to each separate test.

Table 9.--Average survival and total height of released stock expressed as percentages of the averages for unreleased stock[1]

Kind of stock	Survival			Total height		
	Ridge	Flat	Swamp	Ridge	Flat	Swamp
Fresh cuttings:						
10 - 12 inches long	150	438	100	86	140	-
16 - 20 " "	121	256	(2 to 0)	144	130	-
40 " "	112		164	109		82
60 " "	126		100	140		86
Stored cuttings:						
20 inches long	162		(0 to 2)	143		-
Fresh seedlings:						
Cut back to 4 inches	167	102	238	104	114	122
Cut back to 18 - 24 in.	203		117	113		110
Not cut back	143	333	140	100	108	99
Stored seedlings:						
Cut back to 4 inches	100		(0 to 20)	105		-
Cut back to 18 - 24 in.	(20 to 0)		187	-		138
Not cut back	(33 to 0)		122	-		104

[1] When one survival percentage is 0 and the other is 1 or more, the latter is infinitely greater. In such cases, to give a better picture of the actual comparison, both survival percentages are given; e.g., (20 to 0) means that the released stock has the better survival: 20 percent vs. 0 percent for the unreleased stock.

It is evident that partially released stock of all classes generally surpassed unreleased stock in both survival and total height. In general, the partial release was more effective in increasing survival than in increasing total height.

8. Total heights attained in the first growing season. A brief summary of the average total heights attained in the first growing season is given in table 10, based on fresh stock, not released.

Table 10.—Average total height of unreleased stock in October, in inches

Kind of stock	Ridge	Flat	Swamp
Cuttings:			
10 - 12 inches long	7	5	0
16 - 20 inches long	9	8	0
40 " "	23		56
60 " "	30		57
Seedlings:			
Cut back to 2 - 4 inches	24	22	49
Cut back to 18 - 24 inches	38		61
Not cut back	44	25	78

The effect of release on total height is shown in the preceding section. Storage and date of planting had relatively little effect on total height.

9. Form of surviving cuttings and seedlings. In general, the form or straightness of surviving cuttings and seedlings is satisfactory from the standpoint of future sawlog or pulpwood production. The stock on the ridge is especially good in this respect, although a few trees there may not straighten satisfactorily as they grow larger. In the swamp, however, about one-third of the plants have a definitely unsatisfactory form. In most cases, poor form is caused by interference from the extremely heavy ground cover of shrubs, weeds, and vines. Buckvine, the worst offender, has frequently caught and pulled down the young cottonwoods and forced them to grow almost horizontally through entangling vegetation. In some cases the surrounding vegetation has nothing to do with the poor form; the young cottonwoods simply start their new growth above a very crooked or leaning portion of the plant. Grasshoppers, and possibly other insects, also contribute to poor form by eating the terminal buds and by girdling the main shoots. Girdling kills the trees if no new sprouts are put out below the girdle.

Since in most cases the trees with a very unsatisfactory form will have a relatively low commercial value in the future, and in most cases will never even reach commercial size, these trees should be cut back at or very close to the ground during winter or early spring, and thus forced to sprout again. Straight sprouts—but perhaps multiple rather than single sprouts—should result from this treatment. Although the new sprouts may again be caught and deformed by vines, the danger is not so great as before, since the new sprouts will have the advantage of an established root system and probably will outgrow the vines. The need for cutting back about one-third of all stock planted in the swamp makes an extra expense to charge against this site, but it may well be counterbalanced by better survival, better growth, and the probability that in the swamp a planted stand has greater advantages over a possible natural stand than it would have on other sites.

10. Differences in survival between ridge and swamp plantings. Of the 8 plantings of cuttings with survivals of 18 percent or better in October, 6 are on the ridge and only 2 are in the swamp. Of the 13 plantings of seedlings with the same minimum survival, 6 are on the ridge and 7 are in the swamp, with the 2 highest survival percentages in the swamp. Cuttings evidently are far better adapted to the ridge, whereas seedlings are not so sensitive to site but do slightly better in the swamp.

These facts, and several others already discussed concerning depth of planting and length above ground, indicate that survival on the ridge depends largely on having a considerable length in the ground (to obtain sufficient moisture), and only a comparatively short length above ground (so that drying out will not be excessive). The poor survival of 10-inch cuttings on the ridge, for example, is probably due largely to the short length in the ground. Survival in the swamp apparently depends largely on having a considerable length above ground so that the new shoots can begin growth at a level close to or above the tops of the exceptionally dense competing vegetation. The plentiful or excessive moisture in the swamp presumably makes it unnecessary to plant deeply or to leave only a short length above ground. In addition to heavy competition, another condition in the swamp that makes necessary a long length above ground is the frequent presence of standing water deep enough to submerge and kill short lengths.

11. Mortality between June and October, and factors affecting it. In every test the survival recorded in October is lower than the survival recorded in June, and in most cases it is much lower (see tables 2 and 3). The plantings that ranked at or near the top in June usually ranked at or near the top in October also, but there are a few striking exceptions, all in the swamp tests. For example, fresh 20-inch cuttings planted 12 inches deep in early March dropped from 55 to 0 percent survival; fresh seedlings planted in late March and cut back to 4 inches dropped from 73 to 0 percent survival; and stored seedlings planted in late April and cut back to 4 inches dropped from 92 to 18 percent survival. It is notable that all of these plantings are of relatively short lengths above the ground in the swamp.

The plantings showing good results both in June and in October generally had from one-half to two-thirds as high survival in October as at the earlier date. Seedlings as a rule showed lower losses than cuttings during the summer, although on the ridge the best plantings of each class of stock show virtually the same losses. Stored stock showed considerably heavier losses during the summer than fresh stock. With respect to sites, the best plantings of both seedlings and cuttings usually showed smaller losses during the summer in the swamp than on the ridge, whereas the poorer plantings showed exactly the opposite result. Losses between June and October seemed to have no appreciable relation to date of planting.

In most cases, cuttings that were alive in June but dead in October either had no roots or very meager roots, a fact revealed by pulling up many of them in October. Similarly, most of the seedlings that died during the summer probably had no live roots in June. In the swamp, heavy vegetation and late floods probably were largely responsible for killing the tops of many plants that had leafed out in June, weakening whatever root growth had started. It is possible that most of the plants that were leafed out in June had little or no root formation, and that roots did not develop during the summer except under favorable conditions of soil moisture, retention of moisture in the tops, and competition with other vegetation.

12. Effect of rabbit repellent. The rabbit repellent was prepared by stirring 5 pounds of liquid asphalt paint into 3-1/3 quarts of water, adding 3-1/3 pounds of copper carbonate, and then enough water to make up 4 gallons. This was sprayed or painted on the planting stock in 2 of the 4 blocks on the flat, and produced an unexpected result. It proved to be unnecessary to protect the plantings from rabbits, since no rabbit damage was noted later in the untreated blocks. Survival data for treated stock, however, expressed as percentages of the survival of untreated stock on the same site, were as follows:

	June	October
Cuttings	116	157
Seedlings	112	70

It is thought that the differences in favor of the treated cuttings are the result of conservation of moisture brought about by the repellent coating. Probably the asphalt in the repellent was largely responsible for this action. The fact that the seedlings eventually did not survive better in the treated plots fits well into this theory only if it is assumed that seedlings are much less or not at all in need of protection from loss of moisture. This is not unlikely, however, since seedlings benefit from having roots when planted, and tops that generally seem to be less succulent and to have tighter bark than cuttings. For these reasons, seedlings probably are more capable of maintaining adequate moisture.

13. Possibility of improved results through selection of stock. The results discussed in this paper were obtained without careful selection of stock. In the case of cuttings, material was obtained at random from 1-year-old shoots from the upper parts of the crowns of well-developed saplings and small trees without any discrimination other than to discard a few very crooked, weak, or injured shoots. In the case of seedlings, 1- and 2-year-old plants were taken at random, again discarding only very crooked, weak, or injured seedlings. In the use of either cuttings or seedlings, however, especially cuttings, it is probable that careful selection of stock of only a certain appearance or character, or from trees of only a certain appearance or character, will greatly improve survival and growth. At present there is no basis for such selection, but studies designed to explore this field will be commenced soon at Stoneville.

Conclusions and Recommendations

Based on results obtained solely on clay soils and in a single, abnormal growing season, conclusions are necessarily tentative and may be modified by further studies. In view of the demand for information that can be put to immediate practical use, however, it is desirable to present conclusions and recommendations at this time.

Present indications are that wild cottonwood seedlings (wildings) are better than cuttings for planting stock. Seedlings should be obtained and planted before the buds open in the spring, or obtained early and held in cold storage if for any reason the planting can be done only after growth has started. Fresh, dormant stock planted very soon after pulling is preferable, and it must not be allowed to dry out before planting. Seedlings may be obtained from natural stands close to the Mississippi or other large rivers, or in borrow pits and ditches. In swamps and low flats the seedlings should be cut back to about 18 - 24 inches at the time of planting. On ridges or high flats the seedlings should be cut back to about 4 inches if the planting is done at least 2 weeks in advance of the opening of the buds, or if the stock has been stored and is planted after growth has started in the woods; otherwise the seedlings should not be cut back. The seedlings should be approximately 2 years old, or about 4 to 7 feet high, and the roots should be at least 10 inches long.

In view of the probable survival percentages of about 50 percent on ridges and 70 percent in swamps for the first year, a spacing of about 6 x 6 feet seems more suitable than wider spacings. At least one partial release from competition in June appears desirable but not essential. During the dormant period following the first growing season, crooked and deformed seedlings and those interfered with by vines should be cut back just above the ground. Since total heights will probably average about 3 feet on ridges and 5 feet in swamps, it should not be difficult to find the seedlings that will benefit from cutting back.

If seedlings cannot be obtained, cuttings may be used. On ridges or high flats, cuttings should be 20 inches long and planted 16 inches deep. In swamps and low flats, cuttings should be 60 inches long and planted 24 inches deep. The stock should be obtained and planted before the buds open in the spring, and must not be allowed to dry out before planting. Cuttings that do not include the terminal bud are preferable. Recommendations concerning spacing, release from competition, and the cutting back of crooked plants after the first growing season are the same as for seedlings.

OCCASIONAL PAPER NO. 99 May 27, 1941

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TAXES ON FOREST PROPERTY IN NINE SELECTED COUNTIES OF ALABAMA, 1937-40, AND IN SEVEN SELECTED COUNTIES OF MISSISSIPPI, 1936-40

By

Ronald B. Craig, Associate Forest Economist
Southern Forest Experiment Station

The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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Foreword

This report presents data on ad valorem taxes on forest property in Alabama and Mississippi, dealing with both current and recent levies. It is the second release in a series of progress reports, the purpose of which is to present up-to-date information on the general level of assessment and taxation of forest lands in the states of the lower South. The first release (Occasional Paper No. 89 and Supplement) concerned taxes in Mississippi for the period 1936-39. Other states will be brought within the scope of the study as rapidly as possible and annual tax data for each state will be reported.

The Division of Forestry, Alabama Department of Conservation, provided cooperation in both field and office in assembling the data for that State. Information was obtained from local tax records in nine counties selected as representative of forest cover and ownership conditions in all parts of the State (fig. 1). This information has been condensed into one table (table 1), which shows, for the nine counties as a whole and for each county separately, the average assessed values, and the average ad valorem property taxes levied for State, county, and school purposes, per acre of forest land and timber, in the period 1937-40. Also shown are the respective annual indices, derived from an index base that takes the average of the three years 1937-38-39 as 100.

Because of the system of "blanket assessment" employed in Alabama, whereby all rural land owned by a given taxpayer in a county is assessed as a unit, it was not possible in this State to derive separate value and tax data for each forest type and condition class. Tax data on small farm woodlands are also excluded, since such lands are assessed with crop and pasture lands in farm units. In these particulars the information respecting Alabama differs from that respecting Mississippi.

The seven counties of Mississippi selected as representative are shown in figure 2. The eight tables for Mississippi present data on the average assessed values and average ad valorem property taxes per acre of forest land in 1936-40, for the seven counties as a whole and for each county separately. The lands are classified by forest type and condition class, and the tables show also the respective annual indices, taking the average of the three years 1936-37-38 as 100. These data are based on the same sample properties used as a basis for the report on 1936-39 taxes presented in Occasional Paper No. 89, and were obtained from the tax rolls of the selected counties.[1] Whereas data on "tax per acre" for the earlier years included the tax on such standing timber as was assessed on the sample properties in Mississippi, figures for 1940 represent taxes on the land only, not including any timber. The "assessed values per acre" indicated for all years covered by the tables refer to the land only. Under provisions of the timber severance tax act of April 1940, all standing timber in Mississippi is exempt from ad valorem taxes, but a 3-percent severance tax is levied on the value of the forest products at the time and place of severance. This fact should be borne in mind in appraising any trends in forest taxation in Mississippi that may be inferred from the index numbers for 1940.

Besides showing the current levels of assessment and taxation in both States, these data give some indication of recent trends in forest taxation, and in time similar figures covering a longer period will afford a valuable measure of this trend. Obviously these figures do not reveal the taxes levied on any particular property, because there is frequently wide disparity in assessments and total tax rates among individual properties within the same county. They do, however, afford a basis for determining whether an individual property is exceptionally favored or overburdened in regard to taxes.

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[1] These 1940 data in Mississippi were obtained by Junior Forester J. D. Strange, Jr., Div. of State and Private Forestry, Region 8, U. S. Forest Service.

Note: Assistance in the preparation of these materials was furnished by the personnel of Work Projects Administration official project 165-2-64-102.

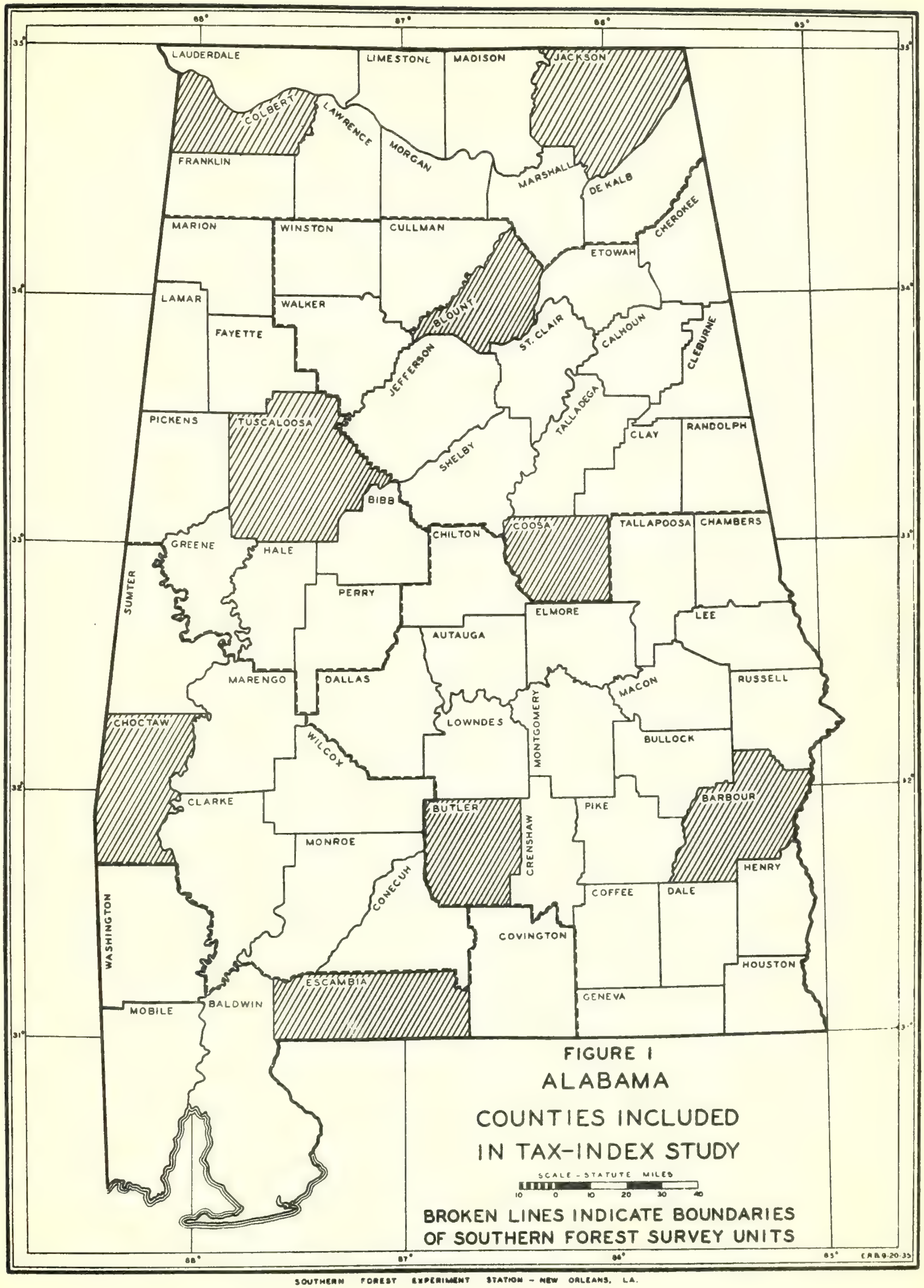

FIGURE I
ALABAMA
COUNTIES INCLUDED
IN TAX-INDEX STUDY

BROKEN LINES INDICATE BOUNDARIES
OF SOUTHERN FOREST SURVEY UNITS

SOUTHERN FOREST EXPERIMENT STATION - NEW ORLEANS, LA.

Table 1.—Forest taxation data for nine selected counties of Alabama, with group averages, 1937-40

County	Average assessed value per acre				Index of value per acre[1]				Average tax per acre				Index of tax per acre[1]			
	1937	1938	1939	1940	1937	1938	1939	1940	1937	1938	1939	1940	1937	1938	1939	1940
	- - - - Dollars - - - -				- - Annual index - -				- - - - Cents - - - -				- - - Annual index - -			
Barbour	2.90	2.90	2.90	2.90	100	100	100	100	6.8	6.8	6.5	6.5	101	101	97	97
Blount	2.89	2.76	2.78	2.71	103	98	99	96	6.1	5.8	5.8	5.7	103	98	98	97
Butler	3.50	3.42	3.11	3.22	105	102	93	96	7.4	7.2	6.5	6.8	106	103	93	97
Choctaw	4.66	4.16	4.09	3.90	108	97	95	91	9.8	8.7	8.6	8.2	109	97	96	91
Colbert	2.70	2.45	2.41	2.26	107	97	96	90	5.7	5.1	5.0	4.7	108	97	95	89
Coosa	2.53	2.48	2.51	2.86	101	99	100	114	5.3	5.2	5.3	6.0	100	98	100	113
Escambia	4.04	4.06	4.03	3.91	100	100	100	97	8.5	8.5	8.5	8.2	100	100	100	96
Jackson	1.32	1.32	1.32	1.32	100	100	100	100	2.8	2.8	2.8	2.8	100	100	100	100
Tuscaloosa	3.04	2.93	2.87	2.71	103	99	97	92	6.4	6.2	6.0	5.7	103	100	97	92
Average[2]	3.06	2.94	2.89	2.87	103	99	98	97	6.5	6.3	6.1	6.1	103	100	97	97

[1] 1937-39 = 100.

[2] Unweighted mean of nine counties.

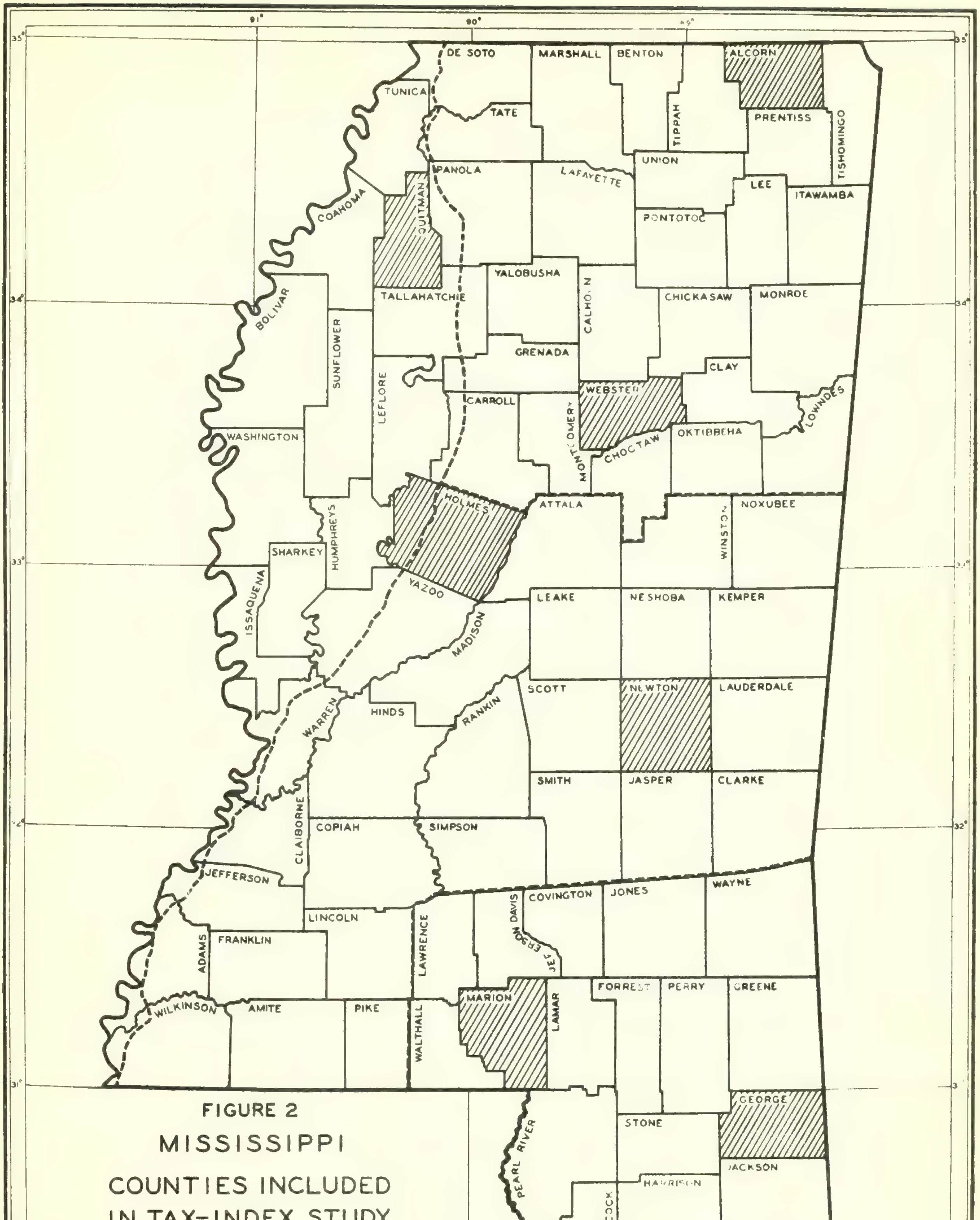

FIGURE 2

MISSISSIPPI

COUNTIES INCLUDED IN TAX-INDEX STUDY

BROKEN LINES INDICATE BOUNDARIES OF SOUTHERN FOREST SURVEY UNITS

SOUTHERN FOREST EXPERIMENT STATION - NEW ORLEANS, LA

Table 2.—Forest taxation data: average for seven counties of Mississippi[1]

Forest type and condition class	Average assessed value per acre[2]			Index of value per acre[3]			Average tax per acre					Index of tax per acre[3]				
	1936-37	1938-39	1940	1936-37	1938-39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	- - Dollars - -			- Annual index -			- - - - - - Cents - - - - - -					- - - Annual index - - -				
Pine:																
Sawlog	3.41	3.00	3.41	104	92	104	24.2	22.2	21.2	22.2	20.5	108	99	94	99	91
Under-sawlog	2.88	2.77	2.81	101	98	99	16.6	14.9	14.4	15.0	16.3	108	97	94	98	107
Clear-cut	2.77	2.66	2.90	101	97	106	16.5	14.8	14.3	14.9	16.8	109	97	94	98	111
Upland hardwood:																
Sawlog	3.19	3.11	3.31	101	98	105	19.8	16.6	17.2	17.5	20.0	111	93	96	98	112
Under-sawlog	2.92	2.80	3.16	101	97	110	16.8	15.0	14.6	15.2	18.0	108	97	94	98	116
Bottomland hardwood:																
Sawlog	3.48	3.32	3.67	101	97	107	23.2	20.9	20.8	21.0	19.5	107	97	96	97	90
Under-sawlog	3.23	3.14	3.39	101	98	106	18.0	16.2	16.8	16.9	18.4	106	95	99	99	108

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[1] Alcorn, George, Holmes, Marion, Newton, Quitman, and Webster Counties.
[2] Assessment is biennial.
[3] 1936-38 = 100.

Table 3.—Forest taxation data: Alcorn County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936-37	1938-39	1940	1936-37	1938-39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	- - Dollars - -			- Annual index -			- - - - - - Cents - - - - - - -					- - - Annual index - - -				
Pine:																
Sawlog	3.86	2.73	3.72	111	78	107	22.3	20.0	15.0	15.4	22.9	117	105	79	81	120
Under-sawlog	2.19	2.48	1.87	96	108	82	10.0	8.7	10.3	11.2	8.9	103	90	106	115	91
Clear-cut	1.50	1.62	1.67	97	105	108	7.2	6.3	7.1	7.4	8.6	104	91	103	107	125
Upland hardwood:																
Sawlog	4.62	4.62	4.52	100	100	98	26.2	21.0	21.7	21.0	23.2	114	91	94	91	101
Under-sawlog	3.62	3.27	3.46	103	93	99	18.6	15.8	15.2	15.8	17.7	113	96	92	96	107
Bottomland hardwood:																
Sawlog	4.27	3.90	4.22	103	94	102	26.8	24.3	27.2	27.4	25.6	103	93	104	105	98
Under-sawlog	3.75	3.38	3.29	103	93	91	19.0	16.1	15.7	16.3	17.2	112	95	93	96	102

[1] Assessment is biennial.
[2] 1936-38 = 100.

Table 4.—Forest taxation data: George County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936-37	1938-39	1940	1936-37	1938-39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	- - Dollars - -			- Annual index -			- - - - - - Cents - - - - - -					- - - Annual index - - -				
Pine:																
Sawlog	3.50	3.50	4.00	100	100	114	20.9	20.1	21.4	23.8	21.6	100	97	103	114	104
Under-sawlog	3.29	3.12	3.70	102	97	115	16.6	14.9	14.3	15.2	20.0	108	97	93	99	131
Clear-cut	3.03	2.95	3.68	101	98	123	15.0	13.5	13.2	14.3	19.5	108	97	95	103	140
Upland hardwood:																
Under-sawlog	3.05	3.01	3.43	100	99	113	15.6	13.9	13.5	14.4	18.3	109	97	94	101	128
Bottomland hardwood:																
Sawlog	3.10	3.00	3.50	101	98	114	17.8	15.6	14.3	15.8	17.8	112	97	92	98	112
Under-sawlog	2.96	2.99	3.79	100	101	128	15.4	14.0	14.0	15.1	20.0	106	97	97	104	138

[1] Assessment is biennial.
[2] 1936-38 = 100.

Table 5.—Forest taxation data: Holmes County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936 -37	1938 -39	1940	1936 -37	1938 -39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	- - Dollars - -			- Annual index -			- - - - - - Cents - - - - - -					- - - Annual index - - -				
Pine:																
Sawlog	2.83	2.78	3.09	101	99	110	13.3	13.6	13.9	14.0	15.7	98	100	102	103	115
Under-sawlog	2.47	2.38	2.72	101	98	111	11.4	11.6	11.6	11.8	13.5	99	101	101	103	117
Clear-cut	2.41	2.32	2.55	101	97	107	12.7	12.2	12.3	12.7	13.8	102	98	99	102	111
Upland hardwood:																
Sawlog	2.28	2.37	2.39	99	103	103	12.4	11.8	13.0	13.1	13.4	100	95	105	106	108
Under-sawlog	2.53	2.63	2.83	99	103	111	12.8	12.9	14.0	14.0	15.2	97	98	106	106	115
Bottomland hardwood:																
Sawlog	4.38	4.36	4.66	100	100	107	22.6	21.7	23.5	23.1	25.0	100	96	104	102	111
Under-sawlog	4.08	4.16	4.23	99	101	103	22.3	21.6	24.2	24.1	24.3	98	95	107	106	107

[1] Assessment is biennial.
[2] 1936-38 = 100.

Table 6.—Forest taxation data: Marion County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936 -37	1938 -39	1940	1936 -37	1938 -39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	- - Dollars - -			- Annual index -			- - - - - Cents - - - - -					- - Annual index - -				
Pine:																
Sawlog	4.00	3.50	3.54	104	91	92	23.4	22.5	21.9	21.7	22.4	104	100	97	96	99
Under-sawlog	3.90	3.37	2.58	105	91	69	22.9	20.5	18.0	17.8	16.9	112	100	88	87	82
Clear-cut	3.74	3.37	3.34	103	93	92	21.2	19.3	17.5	17.5	17.9	110	100	91	91	93
Bottomland hardwood:																
Sawlog	4.02	3.77	3.78	102	96	96	20.8	19.4	19.0	20.1	18.2	106	98	96	102	92
Under-sawlog	4.00	3.70	3.61	103	95	93	21.8	19.8	19.8	18.4	17.8	106	97	97	90	87

[1] Assessment is biennial.
[2] 1936-38 = 100.

Table 7.—Forest taxation data: Newton County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936-37	1938-39	1940	1936-37	1938-39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	Dollars			Annual index			Cents					Annual index				
Pine:																
Sawlog	3.00	3.00	3.00	100	100	100	21.4	18.8	18.8	19.2	17.7	109	95	95	97	90
Under-sawlog	2.97	2.97	3.09	100	100	104	18.6	16.6	17.1	17.4	18.1	107	95	98	100	104
Clear-cut	3.00	3.00	3.12	100	100	104	18.3	16.3	16.3	16.6	17.9	108	96	96	98	105
Bottomland hardwood:																
Sawlog	3.00	3.00	3.00	100	100	100	35.2	31.6	31.4	30.0	15.2	108	97	96	92	46
Under-sawlog	2.99	2.99	3.09	100	100	103	18.6	16.1	16.2	16.5	17.6	109	95	95	97	104

[1] Assessment is biennial.
[2] 1936-38 = 100.

Table 8.—Forest taxation data: Quitman County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936-37	1938-39	1940	1936-37	1938-39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	Dollars			Annual index			Cents					Annual index				
Bottomland hardwoods:																
Sawlog	2.56	2.59	3.58	100	101	139	12.7	11.6	12.5	11.8	14.3	103	94	102	96	116
Under-sawlog	2.44	2.60	2.79	98	104	112	11.6	10.5	12.7	11.8	11.6	100	91	109	102	100

[1] Assessment is biennial.
[2] 1936-38 = 100.

Table 9.—Forest taxation data: Webster County, Miss.

Forest type and condition class	Average assessed value per acre[1]			Index of value per acre[2]			Average tax per acre					Index of tax per acre[2]				
	1936-37	1938-39	1940	1936-37	1938-39	1940	1936	1937	1938	1939	1940	1936	1937	1938	1939	1940
	- - Dollars - -			- Annual index -			- - - - - - Cents - - - - - -					- - Annual index - -				
Pine:																
Sawlog	3.29	2.48	3.09	109	82	102	43.8	38.3	35.7	39.4	22.7	111	97	91	100	58
Under-sawlog	2.46	2.29	2.88	102	95	120	19.9	17.2	15.4	16.8	20.4	114	98	88	96	117
Clear-cut	2.92	2.68	3.02	103	94	106	24.8	21.0	19.2	21.0	23.3	114	97	88	97	107
Upland hardwood:																
Sawlog	2.67	2.33	3.01	104	91	118	20.9	17.1	17.0	18.5	23.5	114	93	93	101	128
Under-sawlog	2.47	2.28	2.92	102	95	121	20.4	17.5	15.5	16.6	20.6	115	93	87	93	116
Bottomland hardwood:																
Sawlog	3.00	2.64	2.98	104	92	103	26.6	22.2	17.0	18.5	20.3	121	101	73	84	93
Under-sawlog	2.40	2.17	2.92	103	94	126	17.0	15.6	14.9	15.9	20.2	108	99	94	101	128

[1] Assessment is biennial.
[2] 1936-38 = 100.